

Lineman Practice

Volume II

For Class XII

Instructional-cum-Practical Manual

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Project Coordinator



राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
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Foreword

The programme of Vocationalization of higher secondary education has been accepted by the country as it holds forth great promise for linking education with the productivity and economic development of the country by providing education for better employability of the youth.

In view of the importance of the programme, the NCERT is making an all-out effort to provide academic support to the implementing agencies in the States. One of the major contributions of NCERT is in the field of curriculum development and in the development of model instructional materials. The materials are developed through workshops in which experts, subject specialists, employers' representatives, curriculum framers and teachers of the Vocational courses are involved.

The present manual, *Lineman Practice* (Volume II), has been developed in the manner described above and is meant for the students studying Lineman and allied vocations. It is being published for wider dissemination amongst students and teachers throughout the country. I hope that they will find the manual useful.

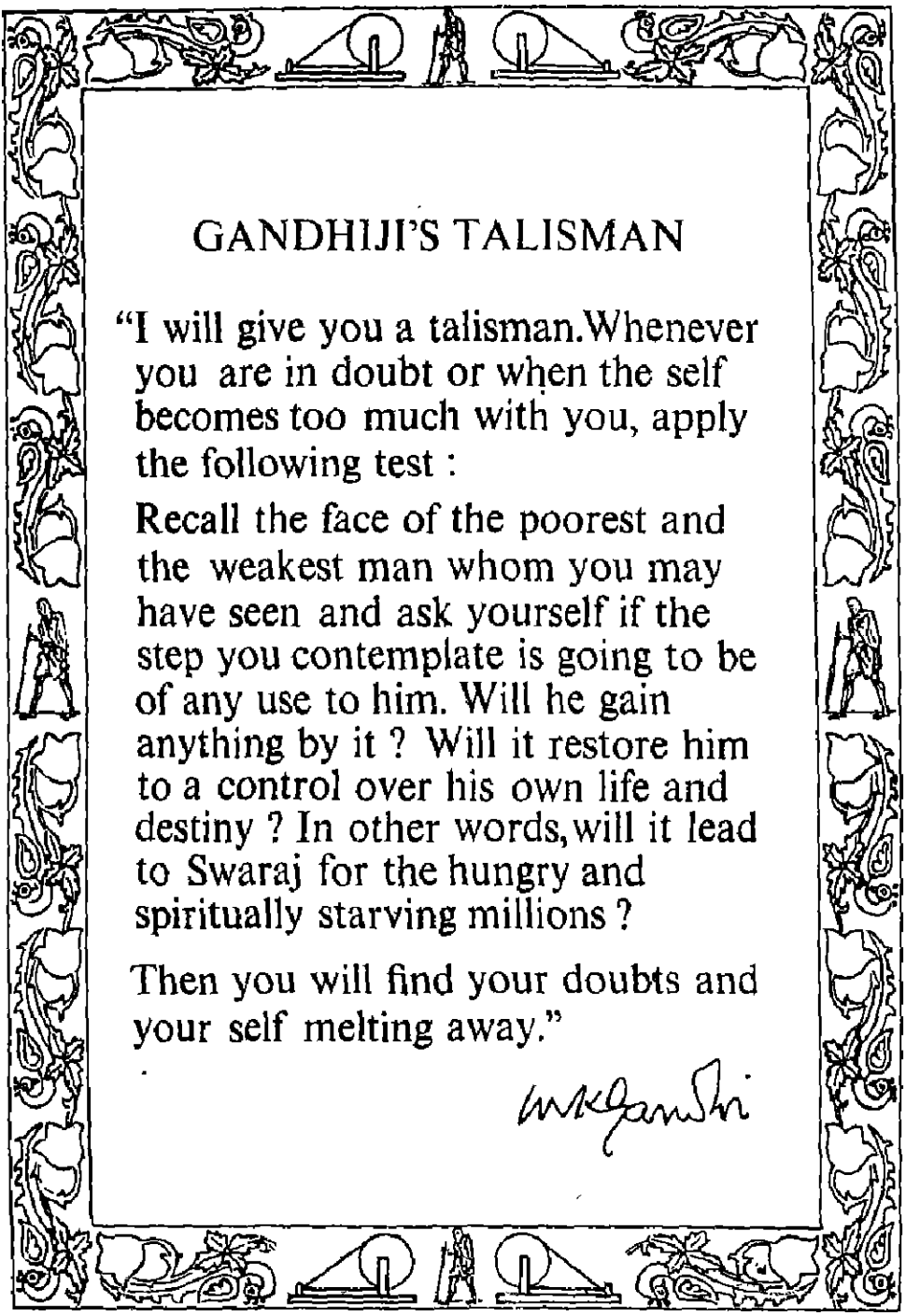
I am grateful to all those who have contributed to the development of this manual. I must acknowledge also the immense interest taken by Prof. A.K. Mishra, Head, Department of Vocationalization of Education in inspiring his colleagues in their endeavours to develop instructional material. Shri S. Ray, Lecturer, functioned as the Project Coordinator for the development of this title. He has my appreciation and thanks for planning, designing and conducting the workshops, for technical editing and for seeing this manual through the press.

Suggestions for improvement of this manual will be welcome.

P. L. MALHOTRA
Director

New Delhi

National Council of Educational Research and Training



GANDHIJ'S TALISMAN

"I will give you a talisman. Whenever you are in doubt or when the self becomes too much with you, apply the following test :

Recall the face of the poorest and the weakest man whom you may have seen and ask yourself if the step you contemplate is going to be of any use to him. Will he gain anything by it ? Will it restore him to a control over his own life and destiny ? In other words, will it lead to Swaraj for the hungry and spiritually starving millions ?

Then you will find your doubts and your self melting away."

M.K. Gandhi

Preface

Ever since the introduction of vocationalization in our school system by several States and Union Territories in our country, the paucity of appropriate instructional materials has been felt as one of the major constraints in the implementation of the programme and a source of great hardship to pupils offering vocational studies at the higher secondary stage.

The Department of Vocationalization of Education of the National Council of Educational Research and Training, New Delhi has started a modest programme of developing instructional materials of diverse types to fill this void in all major areas of vocational education. The task is too gigantic to be completed by any single agency but the model materials being developed by us might provide guidance and impetus to the authors and agencies desiring to contribute in this area. These are based on the national guidelines developed by a Working Group of experts constituted by NCERT.

The present manual is on Lineman Practice (Volume II) and is meant for the pupils and teachers teaching Lineman and allied vocations being offered in a number of States. It contains activities (practical exercises) to be performed by pupils with simple steps to follow, precautions to be taken and data to be recorded and processed. Each activity is complete with objectives, relevant information, procedure, evaluation, etc. It is hoped that the users will find them immensely useful.

The experimental edition of the manual was developed by a group of experts in a workshop held at the Industrial Training Institute, Faridabad. The same was reviewed and revised through a Committee of experts in a workshop held at the National Council of Educational Research and Training. The names of the contributors and reviewers are mentioned elsewhere and their contributions are admirably acknowledged. Shri S. Ray, Coordinator of this project deserves special thanks for editing and bringing the manual into the present form. The assistance of all in the Industrial Training Institute, Faridabad and the Department of Vocationalization of Education, NCERT, is also gratefully acknowledged.

New Delhi

ARUN K. MISHRA
Professor and Head
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The following experts participated in the workshops conducted by the NCERT. Their participation as contributors or reviewers is gratefully acknowledged.

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- | | |
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About the Manual

Under the programme of Vocationalization of Education, about fifty different vocational courses in the area of engineering and technology have been introduced by twelve States and four union territories so far. These courses have been running for the last seven or eight years. From the beginning, the Department of Vocationalization of Education in the NCERT has been working hand in hand with the State organisations concerned, through various programmes organized for State Officials, vocational teachers and others. In fact, by now the Department has conducted on-the-spot studies of vocational programmes in a large number of States to find out the merits and demerits of the programme and to suggest appropriate measures to resolve the problems in "engineering and technical vocational education". These programmes have revealed that there was a great dearth of suitable instructional materials. The need for practical manuals, especially, was urgently felt. The development of instructional materials and the imparting of practical training become even more important when one considers the purpose for which the vocationalization of education was launched. The main aim of the programme was to prepare the pupil for purposeful and gainful employment (wage-employment or self-employment).

The Department constituted a Working Group in 1982 to formulate guidelines for models for a variety of instructional materials. Based on the guidelines formulated by the Working Group, Lineman was selected by the department at the request of the Directorate of Industrial Training and Vocational Education, Government of Haryana, Chandigarh, for the purpose of development of instructional materials in a phased manner. To begin with, the development of instructional-cum-practical manuals have been taken up.

The content of the 'Lineman' course was thoroughly analysed and it was felt that six manuals would be necessary to cater to the needs of the course. The present manual, Lineman Practice (Volume II), is one of them. This manual is intended to help both teachers and pupils. Each activity is complete with specific objectives, related information, equipment and materials, procedure, observations, precautions and questions for evaluation. In order to acquaint the pupils with each activity, the teacher should provide them with required theoretical knowledge related to the activity. This will help the pupils to understand the activity and enable them to perform it properly and effectively.

In order to meet the stipulated objectives, the activities include the study and operation of tools and instruments which a lineman would be required to use in his professional career.

The evaluation of the activities performed by the pupils shall be based on the specific objectives. The teacher shall evaluate all the aspects which are relevant to achieve the specific objectives. This

will contribute towards the "expected behavioural outcome". Evaluation is an important aspect of performing the activities. Each activity should be assessed through evaluation based on knowledge, acquired skills and competencies, attitude and aptitude towards work, activity performance, application, maintenance of activity record. Tabular representation of a suggested evaluation scheme is as follows:

<i>Sl. No.</i>	<i>Components</i>	<i>Marks allotted</i>	<i>Marks awarded</i>
(i)	Knowledge	20	
(ii)	Acquired skills and competencies	35	
(iii)	Attitude and aptitude towards work	15	
(iv)	Activity performance	10	
(v)	Application	10	
(vi)	Maintenance of activity record	10	
Total Marks		100	

At the end of each activity, some questions for evaluation are given. The pupils shall answer these questions on completion of each activity and teacher shall examine them. If required, necessary corrections and suitable suggestions should be incorporated by the teacher. However, the answer to these questions should not be considered for the purpose of awarding final marks or grades.

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ACTIVITY NO. 1

Study and Representation of Transmission and Power Elements

Specific Objectives

- (i) To identify various elements of a transmission system.
- (ii) To state the uses of the elements.
- (iii) To represent the above elements symbolically.

Related Information

- (i) POWER TRANSFORMERS
Symbol

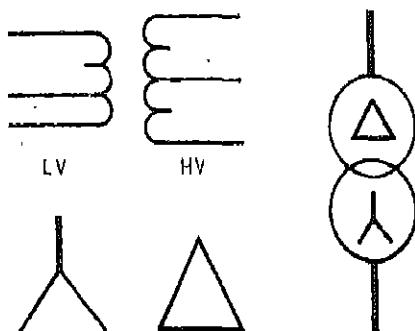


Fig. 1.1 Power Transformer

Uses: Transformers are used in transmission and distribution systems for stepping up or stepping

down voltages.

- (ii) MACHINES
Symbol



Fig. 1.2 Synchronous Machine

(a) Synchronous machines:

Uses: When run as a generator, it converts mechanical energy into alternating current electrical energy. When run as a motor, it converts electrical energy to mechanical energy at constant

speed known as synchronous speed.

(b) *Induction motor*

Symbol

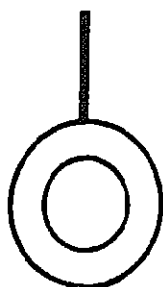


Fig. 1.3.1 Three-Phase squirrel cage induction motor

Uses: Induction motors widely used as A.C. drives.

(c) *D.C. Machines*

Symbol

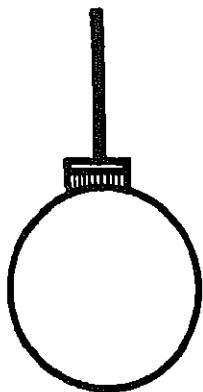


Fig. 1.4 D.C. Machine

Uses: D.C. machines are used either as D.C. generators or D.C. motors.

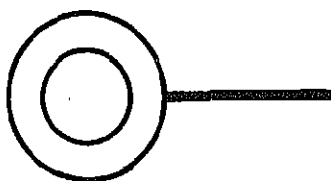


Fig. 1.3.2 Three Phase slip ring induction motor.

(iii) **CIRCUIT BREAKERS** (see Figs. 1.5.1 and 1.5.2)

Uses: Circuit breakers are used as switches either to make or to break the power supply in or supply system, either automatically or manually.

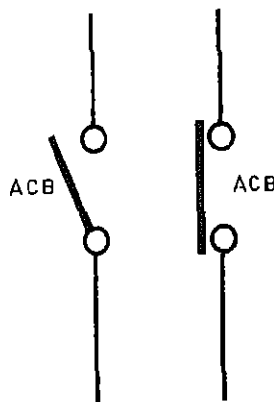


Fig. 1.5.1 Air circuit breaker with over current trip or release.

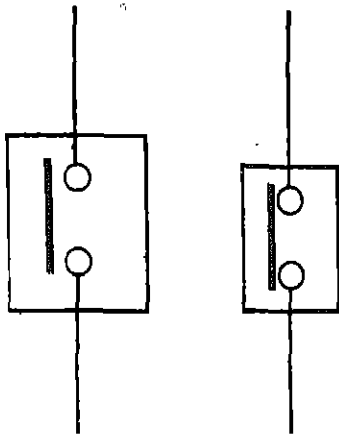


Fig. 1.5.2 High Voltage Circuit breaker (oil, air blast etc.)

(iv) CURRENT TRANSFORMER (C.T.)
Symbol

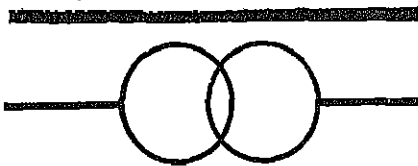


Fig. 1.6 Current Transformer

Uses: It transforms a high current to a low value which will be used for measurement and protection.

(v) POTENTIAL TRANSFORMER (P.T.)

Uses: A potential transformer transforms high voltage to low voltage. It is required for measurement of voltage and protection of equipment.

Symbol

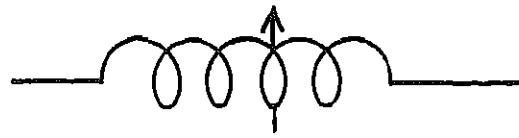


Fig. 1.7 Potential Transformer (P.T.)

(vi) LIGHTNING ARRESTOR

Uses: A lightning arrester is used for protecting line equipment and line insulators against excessive over voltage in the system.

Symbol

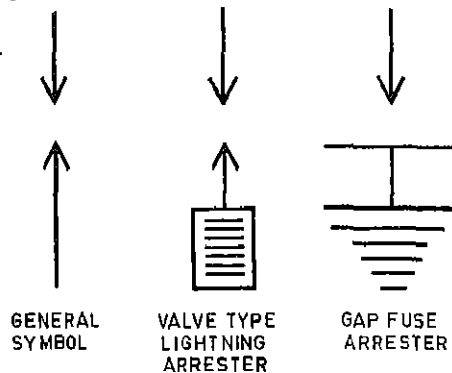


Fig. 1.8 Lightning Arresters

(vii) ISOLATORS

Symbol



Fig. 1.9 Isolator

Uses: Isolators are used to isolate the lines or a component after it has been disconnected by circuit breakers or after the load current has been brought to zero.

(viii) BUS BARS

Symbol



Fig. 1.10 Bus Bar

Uses: Bus Bars are thick conductors used for making multiple connections. They are used in sub-stations, generating-stations,

switch yards, junction boxes etc.

(ix) FUSES

Symbol

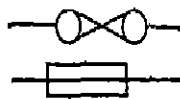


Fig. 1.11 Fuses

Uses: Fuses are used to disconnect the lines in case of excessive current flowing in the line.

Equipment and Materials

The teacher is requested to take the students to a sub-station to familiarize them with the different equipment.

Procedure

- (i) Students should study the different elements in a sub-stations.
- (ii) They should understand the different circuits.
- (iii) They should record their observations during the visit.

Precautions

The students should abide by all the safety rules followed in a sub-station.

Questions

- (i) What is the use of a circuit breaker?
- (ii) What are the purposes of fuses and lightning arrestors?
- (iii) Compare the uses of a fuse and a circuit breaker?

ACTIVITY NO. 2

Drawing a Layout of a Transmission Sub-station

Specific Objective

To familiarize the students with the power elements in a transmission sub-station and to draw the layout.

Related Information

Electric power is generated at the generating stations at voltage levels which are not very high (3.3 K V-18 K V). Presently, generators having generating voltages upto 33KV are being manufactured. This power is transmitted to the load centres at a high voltage known as transmission voltage, since the power transmission capability of transmission lines increases with the increase of the transmission voltage. This high voltage is obtained by stepping up generated voltages by transformers. Typical transmission voltages in India are 66 KV, 132 KV, 220 KV and 400 KV.

The high transmission voltage is stepped down to suitable low levels before power is supplied to the consumers by transformers. A sub-station is a

place where such steps down transformers and other auxiliaries are housed.

The stepping down of high transmission voltages takes place at three stages. For example, a transmission voltage of 132 KV may be stepped down successively to 33 KV, 11 KV and 400 volts. The first sub-station (132 KV/33 KV) is known as a transmission sub-station, the second one (33 KV/11 KV), as a primary distribution sub-station and the third one (11 KV/400 volts) is known as a secondary distribution sub-station. The size of the sub-station is designated by the incoming voltage level and power being handled.

Apart from transformers and bus bars the sub-station houses other auxiliaries like instrument transformers, relays, measuring instruments, circuit breakers, isolators, lightning arresters, wave traps, etc. depending upon the size and importance of the sub-station.

The constitution of a transmission sub-station depends upon the circuits to

be handled by it and, therefore, the main components in such a sub-station are not fixed. However, the main components in a transmission sub-station usually are:

- (i) line trap circuits—for communication at carrier frequency;
- (ii) tap changing transformers and gear main transformers for stepping down the voltage at the desired power level;
- (iii) bus-bars for incoming and outgoing lines;
- (iv) current and potential and transformers for measurement of currents, voltages and for protection;
- (v) circuit breakers for automatic disconnection of lines;
- (vi) isolators for manual and remote control of lines;
- (vii) lightning arrestors for protection
- against excessive over voltages;
- (viii) relays for protection against short circuits and other abnormal conditions;
- (ix) batteries for operation of relays;
- (x) earthing switches for earthing the lines and bus bars during maintenance;
- (xi) station service transformers for supplying low voltage station loads.

The instructors should take the students to a transmission sub-station where all the equipments can be shown to them.

A sample single line diagram for a transmission sub-station is given in Fig. 2.1. It incorporates the main types of equipment with their ratings and connections.

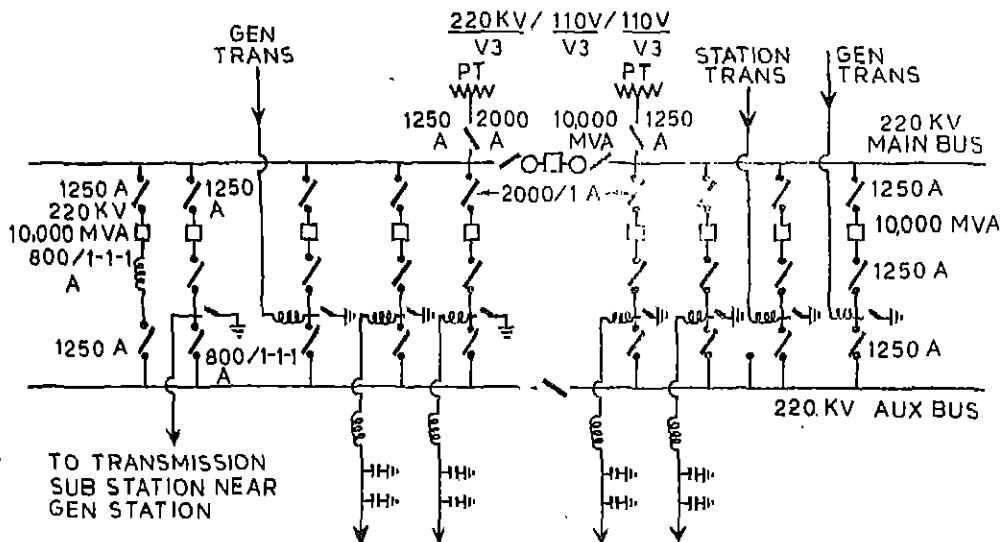


Fig. 2.1 Single line diagram of a 220 KV Switch yard in a Generating Station.

Questions

Procedure

The students should be asked to draw the layout of the transmission sub-station which they are visiting.

Precautions

The students should follow all safety rules while going around the sub-station.

- (i) What are the different types of sub-stations?
- (ii) Draw the layout of the sub-station visited and explain the purpose of the various elements?
- (iii) Write down the ratings of each element on the layout?

ACTIVITY NO. 3

Drawing a Layout of a Distribution Sub-station

Specific Objectives

To make the students familiarize with the elements of the power system at a distribution sub-station and to draw the layout.

Related Information

At the distribution level, the voltage is generally low as compared to that of a transmission sub-station. So the equipment used is of a lower voltage rating. The power handling capacities of the distribution sub-stations are much lower than those of transmission sub-stations. Therefore, the distribution transformers have lower capacities. Moreover, the voltage of the distribution system has to be maintained within specified limits. Fluctuation should be within $\pm 10\%$. So the requirements of the distribution sub-station are different from those of a transmission sub-station. While the equipment in a distribution sub-station is different quantitatively, it is to be found in a transmission station as well. How-

ever, there is some equipment in a transmission sub-station which is not to be found in a distribution sub-station.

The students should be taken for a visit to a distribution sub-station. The teacher should explain the layout and circuit to the students.

A sample layout for a 132 KV/33 KV sub-station is shown in Fig. 3.1. It receives power at 132 KV and steps it down to 33 KV. It is also shown that from 33 KV again it is stepped down to 11 KV by a 33 KV/11 KV transformer and fed to the underground cables.

Procedure

The students should be asked to study the layout of the sub-station they are visiting and familiarize themselves with the different equipment in it.

Tabular records of observations

The students should be asked to draw the layout of the sub-station they are visiting.

Precautions

The students should observe the safety rules while visiting the sub-station.

transmission sub-station and a distribution sub-station?

Questions

(i) What is the difference between a

(ii) Draw the layout of the distribution sub-station visited and mark the ratings of the equipment.

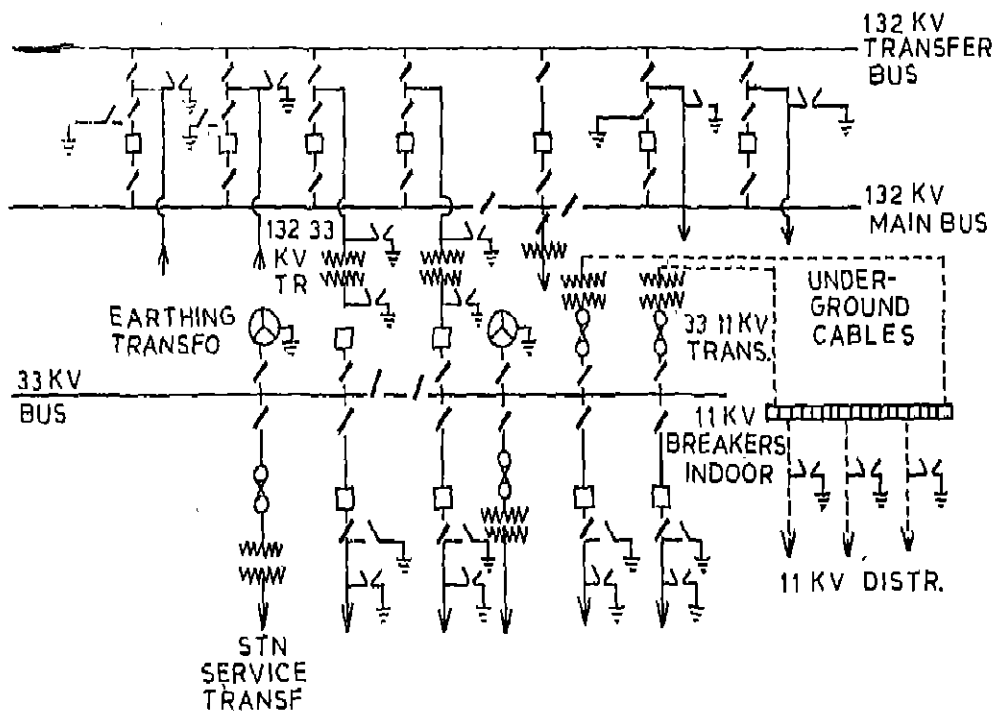


Fig. 3.1 A typical 132 KV/33KV Sub Station

ACTIVITY NO. 4

Observance of Safety Rules for High Tension Work

Specific Objectives

The students will be able to:

- (i) understand the necessity of safety in installing HT cable, overhead line, transformer and sub-station equipment; and
- (ii) practise the laid down Electricity Rules while working on HT installations.

Related Information

All care and precautions should be taken by all concerned to avoid any shock to a person who is either working on energized system or using electrical energy. The responsibility of observing precautionary practices lies on the designers, workers and users. A person gets a shock because of current passing through the body. The shock may be fatal if the current exceeds a safe value, depending on the constitution of the person. The higher the voltage at which a person gets a shock, the more will be the chances of a casualty because the current passing

through the person increases with the increase of voltage. Hence, persons working on HT lines should be extra careful to avoid coming in contact directly with live parts of the electric system.

Considering these risks, certain Indian Electricity Rules have been framed which must be abided by all concerned persons working on H T Lines.

Some of these rules pertaining to cables, earth connection, transformation and control of energy, pole type sub-stations and overhead lines are quoted below from the Indian Electricity Rules, 1956.

Rule 66 : Metal sheathed electric supply lines

Precautions against excess leakage

- 1) The following provisions shall apply to electric supply lines (other than overhead lines) of a supplier for use at high or extra high voltage:
 - (a) The conductors shall be enclosed in metal sheathing

which shall be electrically continuous and connected with earth and the conductivity of the metal sheathing shall be maintained and reasonable precautions taken where necessary to avoid corrosion of the sheathing.

- (b) In the event of a failure of insulation occurring between one conductor and the metal sheathing at any point along an electric supply line as aforesaid, the impedance of the relevant circuit shall be such that with the full voltage maintained at the source of supply, the current resulting from such failure shall not be less than twice the value of the current for which a suitable cut-out of adequate rupturing capacity or other suitable overload protective device has been set to operate or the current required to operate a suitable discriminative fault current relay:

Provided that the operation of the aforesaid overload protective device or of the discriminative fault current relay shall cause the automatic operation of a circuit-breaker of adequate

rupturing capacity.

The relevant circuit hereinbefore referred to means the complete circuit from the source of supply to the point of failure of the insulation, including any connection with earth of the system of which the electric supply line as aforesaid forms part and any current limiting device inserted in such connection with earth; and the source of supply means the point at which energy is given to the system or circuit of which the electric supply line as aforesaid forms part.

- (c) Where an electric supply line as aforesaid has concentric cables and the external conductor is insulated from an outer metal sheathing and connected with earth, the external conductor may be regarded as the metal sheathing; for the purpose of this rule provided that, the foregoing provisions as to conductivity are complied with.

- 2) Nothing in the provisions of sub-rule (1) shall preclude the employment in generating stations, sub-stations and switch stations (including outdoor sub-stations and outdoor switch

stations) of conductors for use at high or extra high voltages which are not enclosed in metal sheathing or preclude the use of electric supply lines laid before the prescribed date to which the provisions of these rules apply.

Rule 67 : Connection with earth

- (1) The following provisions shall apply to the connection with earth of three-phase systems for use at high or extra high voltages:

In the case of star-connected systems with earthed neutral or delta-connected systems with earthed artificial neutral point:

- (a) The neutral point shall be earthed by not less than two separate and distinct connections with earth, each having its own electrode at the generating station and at the sub-station and may be earthed at any other point provided that no interference of any description is caused by such earthing;
 - (b) In the event of an appreciable harmonic current flowing in the neutral connection so as to cause interference with communication circuits, the generator or transformer neutral shall be earthed through a suitable impedance.
- (2) Single-phase high or extra high voltage system shall be earthed in

a manner approved by the Inspector.

- (3) In the case of a system comprising electric supply lines having concentric cables, the external conductor shall be the one to be connected with earth.
- (4) Where a supplier proposes to connect with earth an existing system for use at high or extra-high voltage which has not hitherto been so connected with earth, he shall give not less than fourteen days' notice in writing together with particulars to the telegraph authority of the proposed connection with earth.
- (5) Where the earthing lead and earth connection are used only in connection with earthing guards erected under high or extra high voltage overhead lines where they cross a telecommunication line or a railway line, and where such lines are equipped with earth leakage relays of a type and setting approved by the Inspector, the resistance shall not exceed 25 ohms.
- (6) In so far as the provisions of Rule 61 are consistent with the provisions of this rule, all connections with earth shall also comply with the provisions of that rule.

Rule 68: General conditions as to transmission and control of energy

- (1) Where energy at high or extra

high voltage is transformed, converted, regulated or otherwise controlled in sub-stations or switch-stations (including outdoor sub-stations and outdoor switch-stations) or in street boxes constructed underground, the following provisions shall have effect:

- (a) Sub-stations and switch-stations shall preferably be erected above ground, but where necessarily constructed underground, due provision for ventilation and drainage shall be made;
- (b) Outdoor sub-stations except pole type sub-stations and outdoor switch-stations shall (unless the apparatus is completely enclosed in a metal covering connected with earth, the said apparatus also being connected with the system by armoured cables) be efficiently protected by fencing not less than eight feet in height or other means so as to prevent access to the electric supply lines and apparatus therein by an unauthorized person;
- (c) Underground street boxes (other than sub-stations) which contain transformers shall not contain switches or

other apparatus, and switches, cut-outs or other apparatus required for controlling for other purposes shall be fixed in separate receptacles above ground, wherever practicable.

- (2) Where energy is transformed, suitable provisions shall be made either by connecting with earth a point of the system at the lower voltage or otherwise to guard against danger by reason of the said system becoming accidentally charged above its normal voltage by leakage from a contact with the system at the higher voltage.

Rule: 69 Pole type sub-stations

Where platform type construction is used for a pole sub-station and sufficient space for a person to stand on the platform is provided, a substantial hand-rail shall be built around the said platform and if the hand-rail is of metal, it shall be connected with earth;

Provided that in the case of a pole type sub-station on wooden support and wooden platform, the metal hand-rail shall not be connected with earth.

Rule 74: Material and strength

- (1) All conductors of overhead lines

other than those specified in sub-rule (1) of Rule 86 shall have a breaking strength of not less than 317.15 kg (700 lbs).

- (2) Where the voltage is low and the span is of less than 15.24 metres (50 feet) and is on the owner's or consumer's premises, a conductor having an actual breaking strength of not less than 136.08 Kg (300 lbs) may be used.

Rule 75: Joints

Joints between conductors of overhead lines shall be mechanically and electrically secure under the conditions of operation. The ultimate strength of the joint shall not be less than 95 per cent of that of the conductor, and the electrical conductivity not less than that of the conductor.

Rule 76: Maximum stresses:

Factors of safety

- (1) (a) The owner of every overhead line shall ensure that it has the following minimum factors of safety:
- (i) for metal supports 2.0
 - (ii) for mechanically processed concrete supports 2.5
 - (iii) for hand-moulded concrete supports 3.0
 - (iv) for wood supports 3.5

The minimum factors of safety

shall be based on such load as would cause failure of the support to perform its function (assuming that the foundation and other components of the structure are intact). The aforesaid load shall be:

- (i) equivalent to the yield point stress or the modulus of rupture, as the case may be, for supports subject to bending and vertical loads;
- (ii) the crippling load for supports used as struts.
(The said owner shall also ensure that the strength of the supports in the direction of the line is not less than one-fourth of the strength required in the direction transverse to the line:

Provided that in the case of latticed steel or other compound structures, factors of safety shall not be less than 1.5 under such broken wire condition as may be specified by the State Government in this behalf.)

- (b) The minimum factor of safety for stay wires, guard wires or bearer wires shall be 2.5 based on the ultimate tensile strength of the wire.
- (c) The minimum factor of safety for conductors shall

be 2 based on their ultimate tensile strength. In addition, the conductor tension at 90° F., without external load, shall not exceed the following percentages of the ultimate tensile strength of the conductor:

Initial unloaded tension

35 per cent

Final unloaded tension

25 per cent

Provided that in the case of conductors having a cross-section of a generally triangular shape, such as conductors composed of 3 wires, the final unloaded tension at 90° F. shall not exceed 30 per cent of the ultimate tensile strength of such conductor.

(2) For the purpose of calculating the factors of safety prescribed in sub-rule (1):

(a) the maximum wind pressure shall be such as the State Government may specify in each case;

(b) for cylindrical bodies, the effective area shall be taken as two-thirds of the projected area exposed to wind pressure;

(c) for the latticed steel or other compound structures the wind pressure on the lee-side members shall be taken

as one-half of the wind pressure on the wind-ward side members and the factors of safety shall be calculated on the crippling load of struts and upon the elastic limit of tension members;

(d) the maximum and minimum temperatures shall be such as the State Government may specify in each case.

(3) Notwithstanding anything contained in sub-rules (1) and (2), in localities where overhead lines are liable to accumulations of ice or snow, the State Government may, by order in writing, specify the loading conditions for the purpose of calculating the factor of safety.

Rule 77: Clearance above ground of the lowest conductors

(1) No conductor of an overhead line, including service lines, erected across a street shall, at any part thereof, be at a height less than:

(a) for low and medium voltage line

5.791 metres
(19 ft)

(b) for high voltage line 6.096 metres
(20 ft)

(2) No conductor of an overhead line,

including service lines, erected along any street shall, at any part thereof, be at a height less than:

- (a) for low and medium voltage lines

5.486 metres
(18 ft)

- (b) for high voltage lines

5.791 metres
(19 ft)

- (3) No conductor of an overhead line including service lines, erected elsewhere then along or across any street shall be at a height less than:

- (a) for low, medium and high voltage lines upto and including 11,000 volts if bare

4.572 metres (15 ft).

- (b) for low, medium and high voltage lines upto and including 11,000 volts if insulated

3.963 metres (13 ft).

- (c) for high voltage lines above 11,000 volts. 5.182 metres
(17 ft.)

- (4) For extra high voltage lines, the clearness above ground shall not be less than 17 ft. plus (1 foot) for every 33,000 volts; or part thereof by which the voltage of the lines exceeds 33,000 volts: Provided that the minimum clearance along or across any street shall not be less than 6.096 metres (20 feet).

Rule 78: Clearance between conductors and trolley wires

No conductor of an overhead line crossing a tramway or trolley-bus route using trolley wires shall have less than the following clearances above any trolley wire

- (a) low and medium voltage lines

1.219 metres
(4 ft)

Provided that where an insulated conductor suspended from a bearer wire crosses over a trolley wire, the minimum clearance for such insulated conductor shall be 2 feet.

- (b) high voltage lines upto and including 11,000 volts

1.829 metres (6 ft)

- (c) high voltage lines above 11,000 volts 2.439 metres
(8 ft)

- (d) extra high voltage lines
3.048 metres (10 ft)

Rule 79: Clearance from building of low and medium voltage lines and service lines

- (1) Where a low or medium voltage overhead lines passes above or adjacent to or terminates on any building, the following minimum clearances from any accessible point, on the basis of maximum

sag, shall be observed.

- (a) for any flat roof, open balcony, verandah roof and lean-to roof.
 - (i) When the line passes above the building, a vertical clearance of 8 feet from the highest point,
 - (ii) When the line passes adjacent to the building, a horizontal clearance of 4 feet from the nearest point and
- (b) for a pitched roof:
 - (i) when the line passes above the building a vertical clearance of 8 feet immediately under the lines; and
 - (ii) when the line passes adjacent to the building, a horizontal clearance of 4 feet.
- (2) Any conductor so situated as to have a clearance less than that specified in sub-rule (1) shall be adequately insulated and shall be attached by means of metal clips at suitable intervals to a bare earthed bearer wire having a breaking strength of not less than 700 lbs.
- (3) The horizontal clearance shall be measured when the line is at a maximum deflection from the

vertical due to wind pressure.

Rule 80: Clearance from building of high and extra high voltage lines

- (1) Where a high or extra high voltage overhead passes above or adjacent to any building or part of a building, it shall have, on the basis of maximum sag, a vertical clearance above the highest part of the building immediately under such line, of not less than:
 - (a) for high voltage lines up to and including 33,000 volts. (12 ft.)
 - (b) for extra high voltage line 12 ft plus 1 foot for every additional 33,000 volts or part thereof.
- (2) The horizontal clearance between the nearest conductor and any part of such building shall, on the basis of maximum deflection due to wind pressure, be not less than:
 - (a) for high voltage lines up to and including 11,000 volts (4 ft)
 - (b) for high voltage lines above 11,000 volts and upto and including 33,000 volts. (6 ft)
 - (c) for extra high voltage lines (6 ft) plus 1 foot for every additional 33,000 volts or part thereof.

Rule 81: Conductors at different voltages on the same supports

Where conductors forming parts of systems at different voltages are erected on the same supports, the owner shall make adequate provision to guard against danger to linemen and others from the lower voltage system being charged above its normal working voltage by leakage from or contact with the higher voltage system; and the methods of construction and the clearances between conductors of the two systems shall be subject to the prior approval of the Inspector.

Rule 84: Routes

Proximity to aerodromes

Overhead lines shall not be erected in the vicinity of aerodromes until the aerodrome authorities have approved in writing the route of the proposed lines.

Rule 85: Maximum intervals between supports

All conductors shall be attached to supports at intervals not exceeding the safe limits based on the ultimate tensile strength of the conductor and the factor of safety prescribed in Rule 76. Provided that in the case of overhead lines carrying low or

medium voltage conductors, when erected in, over, along or across any street, the interval shall not without the consent in writing of the Inspector, exceed 220 feet.

Rule 86: Conditions to apply where telecommunication lines and power lines are carried on the same supports

- (1) Every overhead telecommunication line erected on supports carrying a power line shall consist of conductors, each having a breaking strength of not less than 600 lbs.
- (2) Every telephone used on a telecommunication line erected on supports carrying a power line shall be suitably guarded against lightning and shall be protected by cut-outs.
- (3) Where a telecommunication line is erected on supports carrying a high or extra high voltage power line, arrangements shall be made to safeguard any person using the telephone against injury resulting from contact leakage or induction between such power and telecommunication lines.

Rule 89: Service-lines from overhead lines

No service-line or tapping shall be taken off an overhead line except at a point of support.

Rule 90: Earthing

- (1) All metal supports of overhead lines and metallic fittings attached thereto, shall be permanently and efficiently earthed. For this purpose, a continuous earth wire shall be provided and securely fastened to each pole and connected with earth ordinarily at four points in every mile, the spacing between the points being as nearly equidistant as possible. Alternatively, each support and the metallic fitting attached thereto shall be efficiently earthed.
- (2) Each stay wire shall be similarly earthed unless an insulator has been placed in it at a height not less than 10 ft. from the ground.

Rule 91: Safety and protective devices

- (1) Every overhead line (not being suspended from a dead bearer wire and not being covered with insulating material and not being a trolley wire) erected over any part of a street or other public place or in any factory or mine or on any consumer's premises shall be protected with a device approved by the Inspector for

rendering the line electrically harmless in case it breaks.

- (2) An Inspector may, by notice in writing, require the owner of any such overhead line, wherever it may be erected, to protect it in the manner specified in sub-rule (1).
- (3) The owner of every high and extra high voltage overhead line shall make adequate arrangement to the satisfaction of the Inspector to prevent unauthorized person from ascending any of the supports of such overhead lines without the aid of a ladder or special appliances.

The students shall be taken to a high tension line construction site for a visit. The teacher should explain the relevant rules to the students for better understanding.

Questions

- (i) Why are safe practices used in H.T. work?
- (ii) What will be the minimum ground clearance above ground for a 33 KV overhead line running across a street?
- (iii) What will be the minimum breaking strength of an overhead conductor?

ACTIVITY NO. 5

To Make a Jumper Connection

Specific Objectives

To connect a jumper neatly over two conductors of adjacent spans of a section in a transmission/distribution line.

Related Information

Jumpers are short length conductors generally used to connect two conductors of adjacent spans terminated at the section point of the transmission/distribution line. The conductor used in the jumper should be of the same material and size as that of line conductors. The joining of the jumpers with the line conductor can be done by means of clamp or binding wire. Where binding wire is used, soldering of the joint is preferable so as to give maximum contact between the conductors at the joints. Jumpers are not supposed to carry any mechanical load of the line. But the jointing of jumpers with the line conductor should be such that it does not impair the electrical continuity of the line and it should have the same electrical property as that of the line conductor.

Jumpers are also used extensively in a sub-station to connect equipments like circuit breaker/isolator or line terminal conductors with the bus bar. The connections between the cable box terminal mounted on O/H line structure and O/H line conductors are also made through jumpers. A jumper on a section pole x is shown Fig. 5.1.

Equipment and Materials

- (i) Conductors 15 metre length (metal and size same as the line conductor)
- (ii) Parallel groove clamps-6/binding wire.
- (iii) Aluminium tape
- (iv) Hacksaw
- (v) Combination pliers
- (vi) D.E. spanner set
- (vii) Lineman's safety belt
- (viii) Earth chain
- (ix) Ropeline—1 length 12 mm diameter and 40 ft length.
- (x) Ball pein hammer

- (xi) Measuring tape
- (xii) Emery paper.

Procedure

- (i) After ensuring that the line is dead/isolated and properly earthed, climb onto the pole structure to take the measurement for the length of the conductor that would be required for each jumper, and then climb down.
- (ii) Cut down 3 lengths of the conductor with the hacksaw as per the measurement taken.
- (iii) Scrape bright the two ends of each jumper with the emery paper.
- (iv) Now climb up the pole after fastening the safety belt and rope line on your waist.
- (v) On reaching at the top of the pole, take your position after fastening the safety belt securely on the pole or line conductors, as the case may be.
- (vi) Wrap aluminium tape on the line conductor at the point where the jumper is to be connected. Wrap the end of the jumper also similarly.
- (vii) Loosen the nut bolts of the P.G. clamp and place the conductor in one groove and the jumper end in the other groove. Tighten the nut bolts of the P.G. clamps.
- (viii) Take the other end of the jumper over or below the cross arm and

connect to the relevant conductor of the opposite span as was done in operation (vi) and (vii).

- (ix) If the jumper is taken over the cross-arm, bind it with the pin-type insulator provided for the same on the cross arm.
- (x) Complete the jumpers of the other two phase line conductors.
- (xi) After ensuring that all the connections are properly tight, send back all the tools and left over materials by the rope line.
- (xii) Remove the earth chain, unfasten the safety belt and climb down.

Precautions

- (i) Before starting work on the line conductors, locally earth them by means of an earth chain.
- (ii) Fasten the safety belt properly before taking the working position on the pole/conductor.
- (iii) See that nobody is standing below the conductors where jumpering is done, to avoid injury by falling tools, etc.
- (iv) Check that the jumpers are not loose.
- (v) Before climbing down, make sure that all materials and tools have been removed from the pole top and the earth chain too has been removed.

Questions

- (i) Where are jumpers provided in

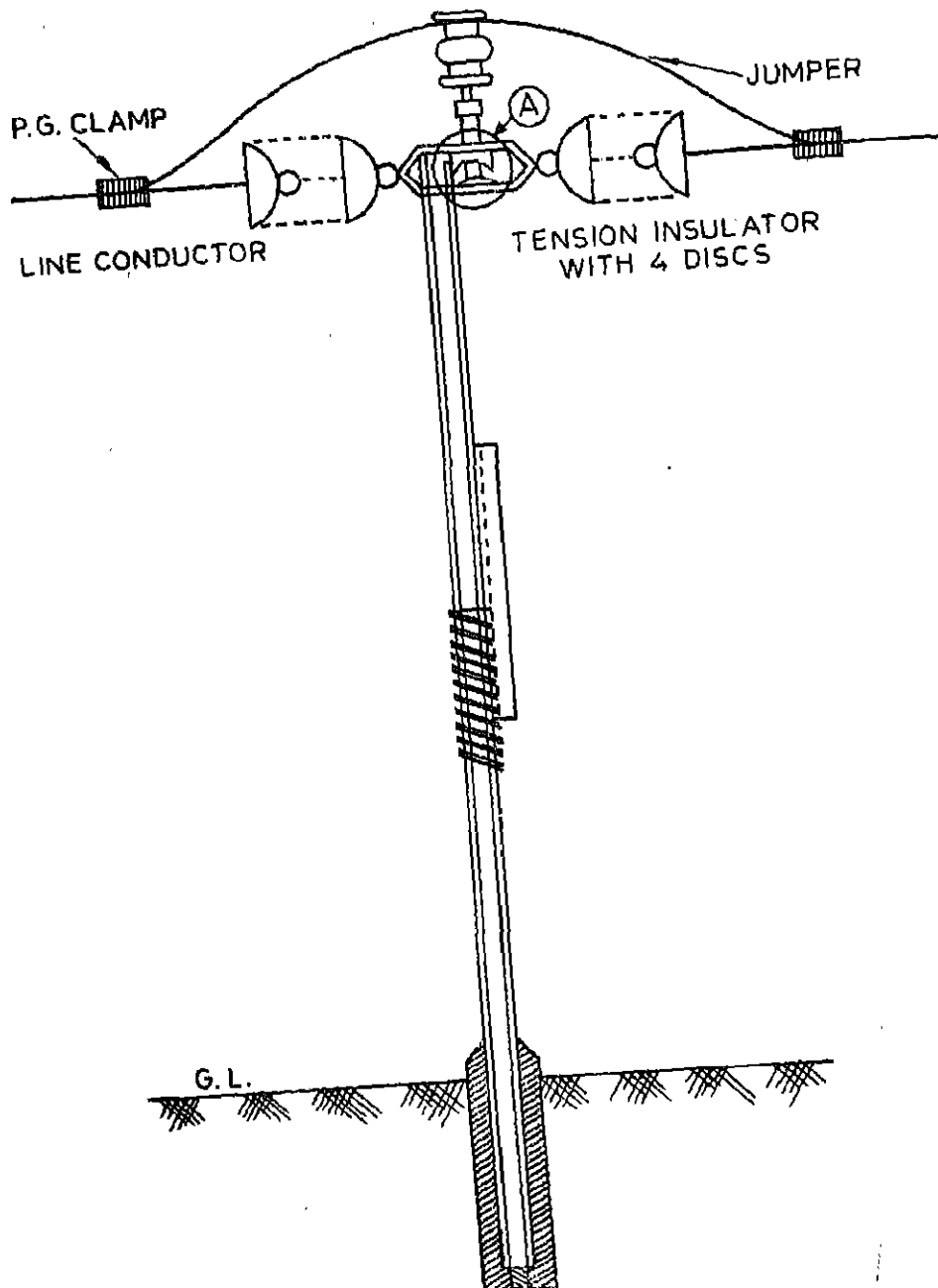


Fig. 5.1 Jumper on a Section Pole

- transmission and distribution lines?
- (ii) What type and size of conductor would you use while making a jumper on an O/H line?
- (iii) What equipment would you carry for your personal safety when you climb up a O/H pole for doing a jumper connection?

ACTIVITY NO. 6

Erection of Transmission Towers

Specific Objectives

The students will be able to familiarize themselves with:

- (i) different types of towers;
- (ii) earth work required before erection;
- (iii) erection of a tower.

Related Information

Transmission towers are required for running high tension lines to transmit electrical power to long distances. Generally, these are of two types:

- (i) Flexible frames
 - (ii) Rigid frames
- (i) *Flexible frames*: These are heavier structures than poles but lighter than rigid towers. Generally, they are rectangular in shape and become narrow towards the top as shown in Fig. 6.1.
- (ii) *Rigid towers*: These are commonly called transmission towers which are the heaviest in struc-

ture, as shown in Fig. 6.2.

Tower Anchors: For erection of a tower, it is necessary to make the base of the tower such as to take the mechanical load (both transverse and longitudinal) transmitted through the tower. For this purpose, the footing is made of concrete with anchors embedded in it. Different methods of concrete anchors are shown in Figs. 6.3.1, 6.3.2, 6.3.3.

Erection of Tower: Generally, there are two methods for erecting towers:

- (i) assembling in the permanent position; and
 - (ii) assembling on the ground.
- (i) *Assembling in the permanent position*: In this method, the tower is erected gradually by assembling the tower structure part by part at the permanent position, i.e. at the base constructed earlier. This method is commonly practised because of its convenience.

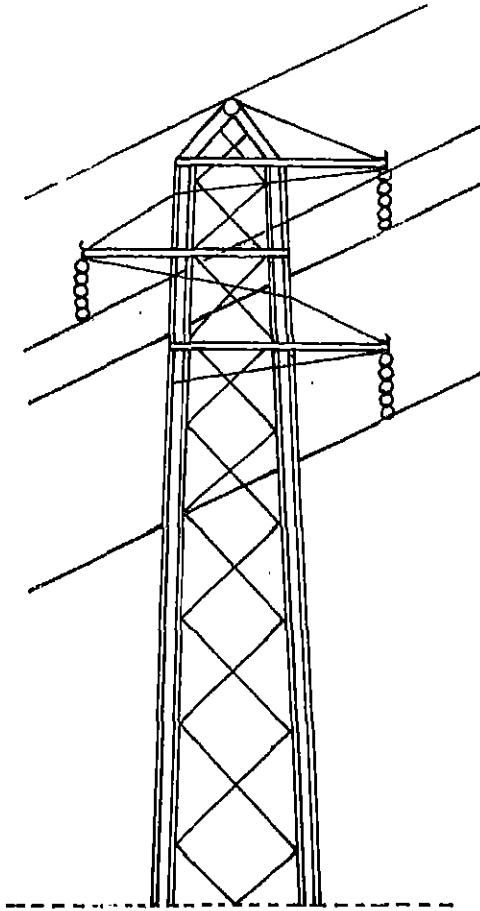


Fig. 6.1 Flexible frame for single circuit 65,000 volt line Transmission Tower

- (ii) *Assembling on the ground* : In this method, the tower is assembled on the ground near the base. Finally, the completed structure is erected with the help of cranes and ropes on the base. It is better to make the base before assembling the structure.

Some operational difficulties are encountered in this method of erection.

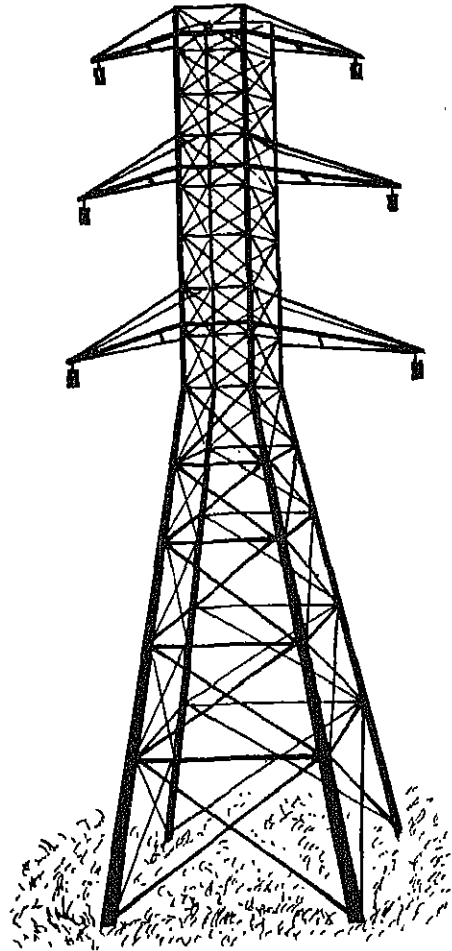


Fig. 6.2 Transmission Tower

Equipment and Materials

- (i) Equipment necessary for digging.
- (ii) Steel ropes
- (iii) Tractors and cranes
- (iv) Spanners and wrenches

- (v) Concrete, bricks and masonry materials
- (vi) Tower members
- (vii) Anchors.

Procedure

The tower size and variety mainly depend upon the voltage of transmission, number of circuits, insulation levels and span between two towers. The controlling factors in the design of a tower are the soil condition, weather conditions, route of transmission line, mechanical loading and conductor weight. Therefore, for proper erection of a tower, the following procedure is adopted.

- (i) All the route points in the length of transmission are marked by putting steel rods at the points.

- (ii) The base area is to be dug as per the drawing supplied. After the area is dug to the proper depth, the earthing pit base is made and measurement of the tower footing resistance is conducted. The dug area is then filled with concrete and the anchor embedded according to specifications provided by the department of erection and the manufacturer, by a mutual agreement.

- (iii) After the foundation is ready, the structure is assembled and fitted to the base in parts sequentially.

- (iv) Cross arms are then fitted on the towers as per specifications.

- (v) The students should draw sketches of the base, frame/tower structure with dimensions.

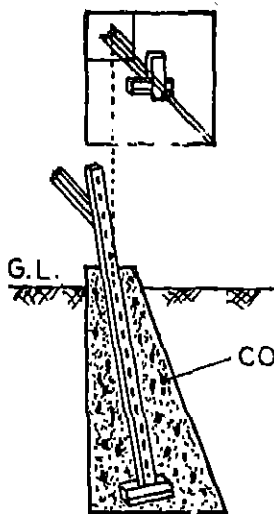


Fig. 6.3.1

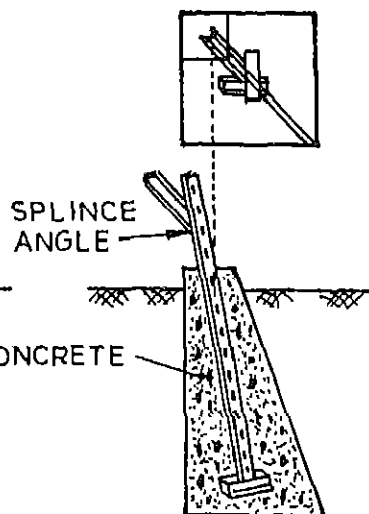


Fig. 6.3.2

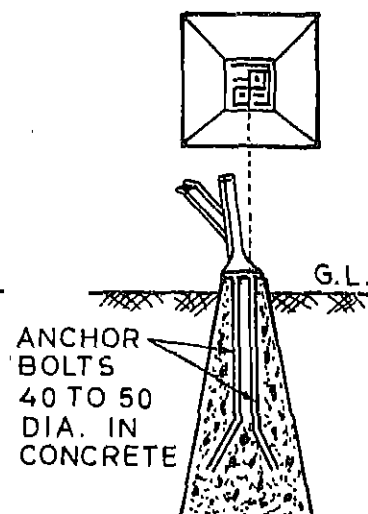


Fig. 6.3.3

Various Concrete Anchors

Precautions

The students should abide by the precautions to be followed at the site.

Questions

- (i) Why are towers necessary?
- (ii) What are the types of transmission towers?
- (iii) Which type of tower have you studied during your visit?
- (iv) Why are anchors necessary for erecting towers?

Note

- (i) The teacher should arrange for the students to visit a tower construction site and ask the students to follow the practices adopted there.
- (ii) The tower erection will be strictly as per the specifications supplied by the tower manufacturer in consultation with the authorities of the concerned electricity board.

ACTIVITY NO. 7

To Draw Conductors on Towers and to Pull up for Correct Sag and Tension

Specific Objectives

- (i) To know the method of placement of conductors on towers
- (ii) To know the techniques of stringing the line.
- (iii) To understand the methodology of installation of power lines.

Related Information

It is known that transmission conductors consist of a group of conductors having the capability to carry heavy current at high voltages over long distances. These conductors are generally of the ACSR variety. They possess the capability of high tensile strength and low resistance in ohms/km. due to a large cross-sectional area.

For this purpose, stringing and pulling constitute an important exercise. For each span length the sag, tension and other mechanical constraints are specified. Therefore, it becomes necessary to draw conductors on a tower and to pull them up to meet correct sag and tension spe-

cifications. This necessitates following a systematic detailed procedure. Straight line support for 33 kv lines using 90/105 lbs rail is showing Fig 7.1

Equipment and Materials

- (i) Conductors-Dog ACSR
- (ii) Earth wire 7/16 SWG GS wire
- (iii) Armour rods
- (iv) Armour rod ferrules
- (v) 20 mm. dia stay rods complete
- (vi) Stay wire 7/8 SWG GS of 70 kgf/mm
- (vii) Pulling equipment
- (viii) Power driven hydraulic compressor for jointing conductor.
- (ix) Spanners
- (x) Rope 25 mm dia
- (xi) Megger 1000 V—one
- (xii) Spring balance 150 kg.—one
- (xiii) Binocular—one
- (xiv) Thermometer—one

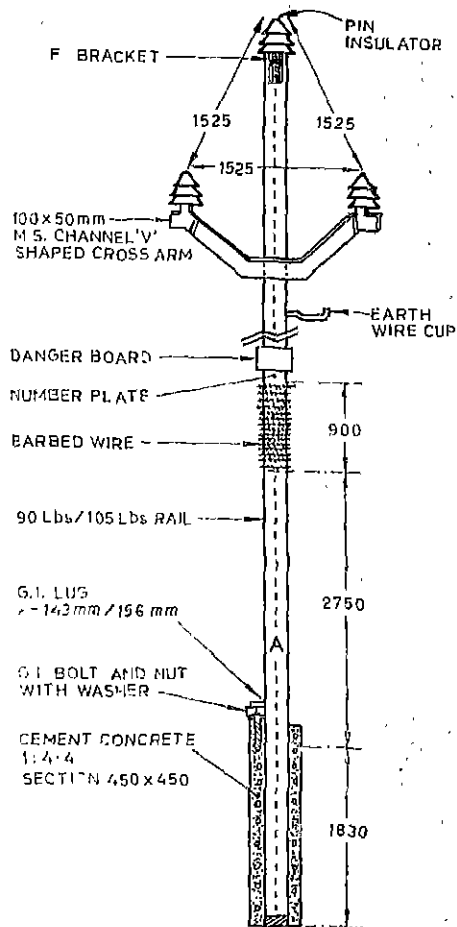


Fig. 7.1 Straight line support for 33 KV lines
90/105 Lbs Rail

Procedure

A good practice is to run the conductors from the top of the drums. The conductor in 33 KV lines is generally pulled

manually. As the conductors are pulled out, they are raised at the support by a rope and block and placed in running snatch blocks, snatch box for ACSR have wooden frames and aluminium sheaves. Blocks must be ample size for the conductors and slings supporting them should be of the correct length. The slings on the locks at tensioning points must be strong enough to withstand the loads imposed during tensioning and it is necessary that they are fitted at the correct point of attachment, otherwise damage to the cross arm may result. Great care must be made by the drum attendant to prevent kinking of conductors.

On the completion of stringing, the tensioning operations commence. The tension insulator sets complete with damped conductors are erected at the end remote from the tensioning points. At the tensioning end, the snatch blocks are fitted on the cross arms. Underneath the slings, fixing the blocks to the cross arm, the sacking is unwrapped to prevent the slings being out. During the preparation, all the mid-span tension joints are made and care should be exercised to keep all joints at least 10 metres away from a support. The tensioning gear depends to a great extent upon the size of the conductor being handled. Tensioning is done with block and tackle but it can also be done more conveniently with a winch. All derricks are removed and the snatch box is adjusted at angle points. It is essential that the conductors should be

straightened out before any tensioning takes place.

All clamps used for pulling up the conductors should be of the correct type and dimension. This applies especially to ACSR clamps which must grip both aluminium and steel properly. By means of the pulley-block and a come-along clamp, one conductor is pulled up to sag and secured to the ground anchor.

A span should be chosen for sagging approximately in the middle of the section. This should be as near the length of the basic span as practicable and, where suitable, supports of equal height should be chosen. The sag is obtained from the sag chart for the corresponding temperature and span length and the figure so obtained is the sag to which the conductors are selected. In the case of pin insulator lines, the distance corresponding to the sag is measured from the insulator groove down the support and marked. In the case of suspension insulator lines, the distance measured down the support must be the sag value plus the length of the insulator assembly.

For checking the sag, one has to look over the batten on one support to the batten on the next and judge when the bottom of the conductor sag is in the level with the line of sight.

Sag for all conductors should be checked as above. Each wire should be sagged according to the sag temperature chart prepared for it.

Tabular Record of observations

Sr. No.	Tension in the conductor	Sag- according to chart	Actual sag.	Remarks
(i)	Phase R			
(ii)	Phase Y			
(iii)	Phase B			
(iv)	Earth wire			

Precautions

- (i) The stringing must be done carefully for all the three conductors.
- (ii) The pulling up of the conductor to the specified sag and tension should be done till it is close to the desired value.
- (iii) Kinks in the conductors should be eliminated.
- (iv) Sag points should be fixed while the pulling operation takes place.
- (v) Derricks should be employed wherever there is a road, river, communication circuit, railways and power circuits crossing.

Questions

- (i) Why is it necessary to have correct tension and sag in power lines?
- (ii) What information do you get from the sag tension chart?
- (iii) What is the difference in the sag levels of main conductors and earth wire?
- (iv) Why are derricks employed at crossings?

ACTIVITY NO. 8

Study of Different Types of Line Insulators

Specific Objective

To familiarize the students with different types of insulators used on overhead high tension lines.

Related Information

The function of a line insulator is to insulate the line conductors from the pole or the tower. Three classes of insulators are used on high tension overhead lines. These are (a) pin type; (b) suspension type; and (c) strain type.

Pin type: The pin insulator gets its name from the fact that it is supported on a pin. The pin holds the insulator and the insulator has the conductor tied to it. Pin insulators are made of either porcelain or glass. The glass insulator is always one piece of glass, that is, it is a one-piece insulator. The porcelain insulator is also a one-piece insulator up to a voltage rating of 33 KV. Above this voltage, the insulator consists of two or three layers cemented together to form a rigid unit. Pin type insulators are shown in Fig. 8.1.

In India, pin type insulators are used extensively in 3.3 KV, 6.6KV, 11 KV lines and 33 KV lines. Above 33 KV, pin insulators are generally not used.

Suspension insulators: The suspension insulator is suspended from the cross arm and has the line conductor fastened to the lower end. The suspension type of insulators are always used for system voltages above 33 KV. These are never used for system voltages below 33 KV. At higher voltages, pin insulators become quite heavy and it becomes difficult to obtain sufficient mechanical strength in the pin to support the insulator.

The suspension insulator consists of a number of identical insulator units, depending upon the system voltage. Each unit consists essentially of two metal pieces insulated from one another with porcelain. First, the porcelain is cemented into the metal cap or the top of the unit and then the metal pin on the bottom of the unit is cemented into the porcelain. Individual units can be connected to form

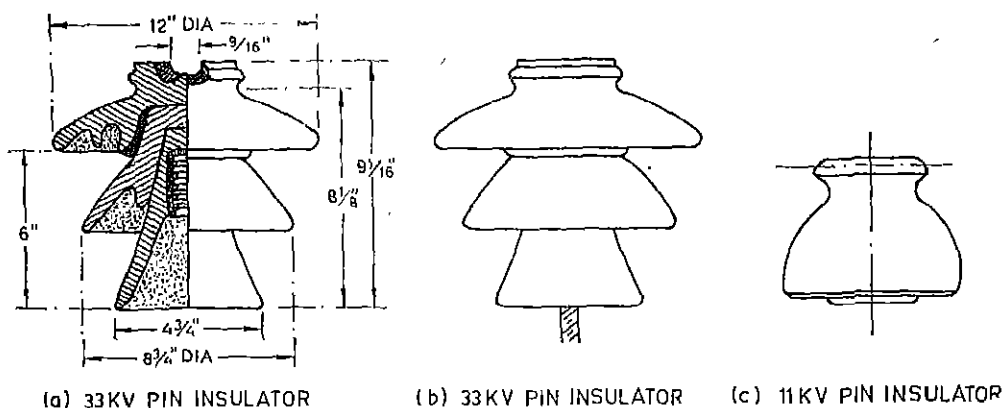


Fig. 8.1 Pin Insulators

a string by successively connecting the pin of one unit to the cap of another unit. Fig. 8.2 shows a typical string of suspension insulator and Fig. 8.3(a) shows one unit of the string.

The number of units to be used in a string depends upon the system voltage and the following Table gives the number of units used in India.

System voltage	No. of units
33 KV	2 to 3
66 KV	4 to 5
132 KV	8 to 10
220 KV	13 to 16
400 KV	22 to 25

Strain insulators: Strain insulators are used where a pull must be carried as well

as insulation provided. Such places occur where a line is dead-ended, at corners,

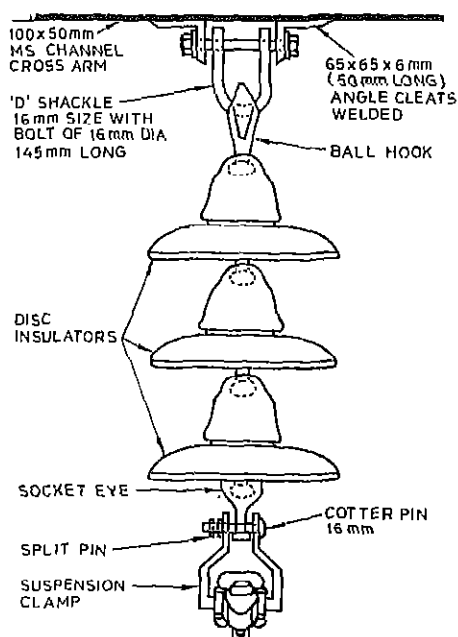


Fig. 8.2 Suspension Insulators String

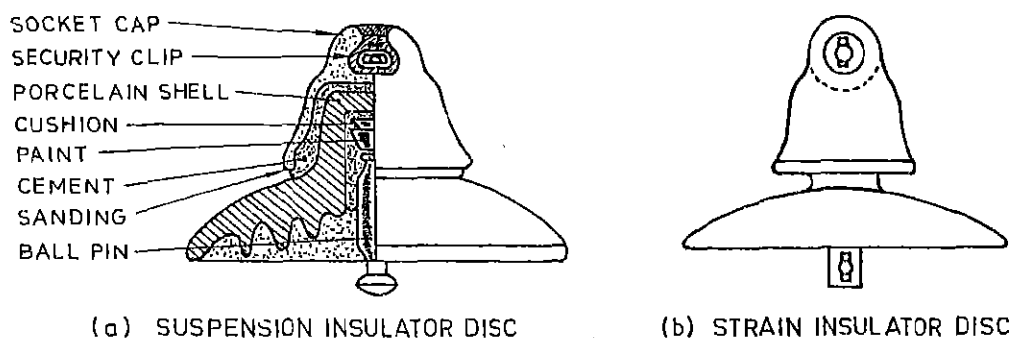


Fig. 8.3 Suspension and Strain Insulator Discs

at sharp curves and at extra long spans. In such places, the insulator must not only be a good insulator electrically, but must also have sufficient mechanical strength to counter-balance the forces due to the tension of the line conductors. Strain insulators are built in the same manner as suspension insulators except that they are made stronger mechanically. Strian insulators are put in a horizontal position. When a single string is not able to withstand the mechanical stress, two or more strings are arranged in multiples. Fig. 8.3(b) shows a strain insulator disc.

Equipment and Materials

Sl. No.	Items	Range or rating	Quantity
(i)	Pin type insula-11 KV		1
(ii)	lor Suspension type11 KV/Unit of insulator units	2 to 3	..
(iii)	Wrench set		

Procedure

- Study the insulator properly, so that sectional views can be drawn.
- Fix up the suspension units to form a string.

Observations

Draw different sectional views of the insulators.

Questions

- Why are pin type insulators not used at higher voltage?
- On what factor does the number of units of a suspension insulator depend?
- Where do strain insulators have to be used?

Note:

The students should first study the insulator and then they should be taken to the site by the teachers for explaining the different insulators to them.

ACTIVITY NO. 9

Installation of Vibration Dampers

Specific Objectives

- (i) To state the necessity of vibration dampers.
- (ii) To install vibration dampers (stock bridge dampers).

Related Information

The vibrations of the overhead line conductors due to wind or storm may cause swinging of the conductors. If the clearances and spacings between the conductors are enough so that they do not come very close to each other during swinging to cause flashover, it is not harmful. The line clearances are so designed that under normal windy or stormy condition, there is no chance of flashover.

However, there may be vibration of conductors due to the formation of eddies in the air on the lee-side of the wires. If ice forms on the conductors, the area of the conductors increases against wind pressure and vibration increases to such a level as to break the conductors at the support ends.

The vibration in the conductors is reduced by clamping weights or dampers on the conductors. The dampers help in preventing the vibration of the conductors reaching the supports and, thus, protect the conductors from breakage due to vibration.

There are two types of dampers used in transmission lines. They are

- (i) Stock bridge dampers
- (ii) Bates type parallel wire dampers

These dampers are shown in Figs. 9.1 and 9.2 respectively. The weight of a damper varies according to the conductor size.

Equipment and Materials

- (i) Safety belt-1
- (ii) Spanner set 1/4", 3/8", 1/2"-2 sets.
- (iii) Earthing rods and earth chain-3
- (iv) Stock bridge dampers-6 sets complete with clamps. (Weight 10-11.6 lbs)
- (v) Transmission line ACSR

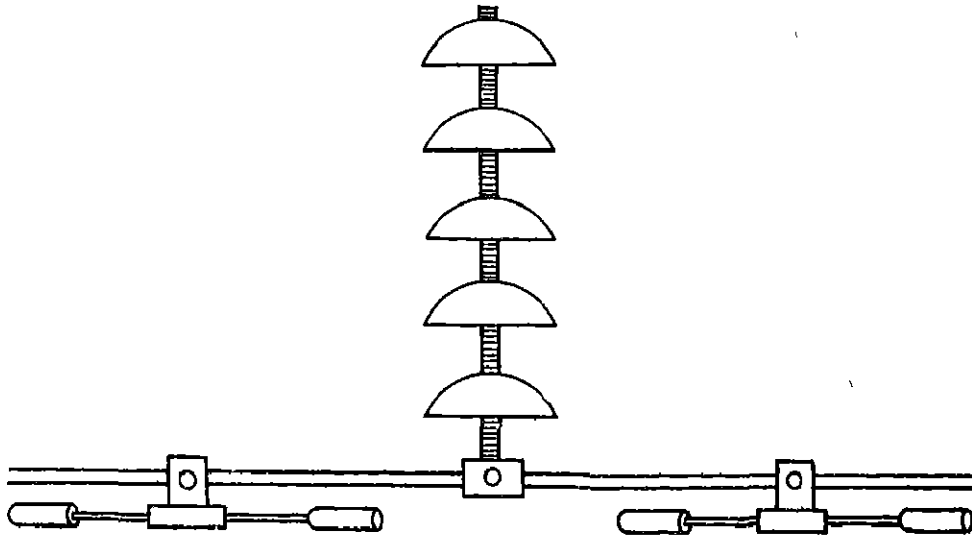


Fig. 9.1 Stock Bridge Damper

37/0.110"

- (vi) Aluminium tape-3 metres
- (vii) Rope line-1 set.

Procedure

The dampers are to be connected to the lines just after the clamping of the conductors to the insulators is over and it is supposed that the line is dead and has been earthed at the ends. The procedure given here is only for stock bridge dampers which are commonly used in India.

- (i) Make sure that the line clearance forms have been signed and clearance has been taken.
- (ii) Make sure that the line is earthed at both ends.
- (iii) Fasten the safety belt to your waist properly and tie the rope line to your belt.
- (iv) Climb up the tower and position yourself at the cross arm, near the conductor insulation strings.
- (v) Tie your safety belt rope securely on the cross arm.
- (vi) Collect the tools like spanners, earthing chain, earth rods, aluminium tape, damper (one no.) with the help of line rope.
- (vii) Use the earthing rods, earth chain effectively on the lines and earth them.
- (viii) Measure 3.75 ft. from the suspension insulator clamping point and mark it by the use of aluminium

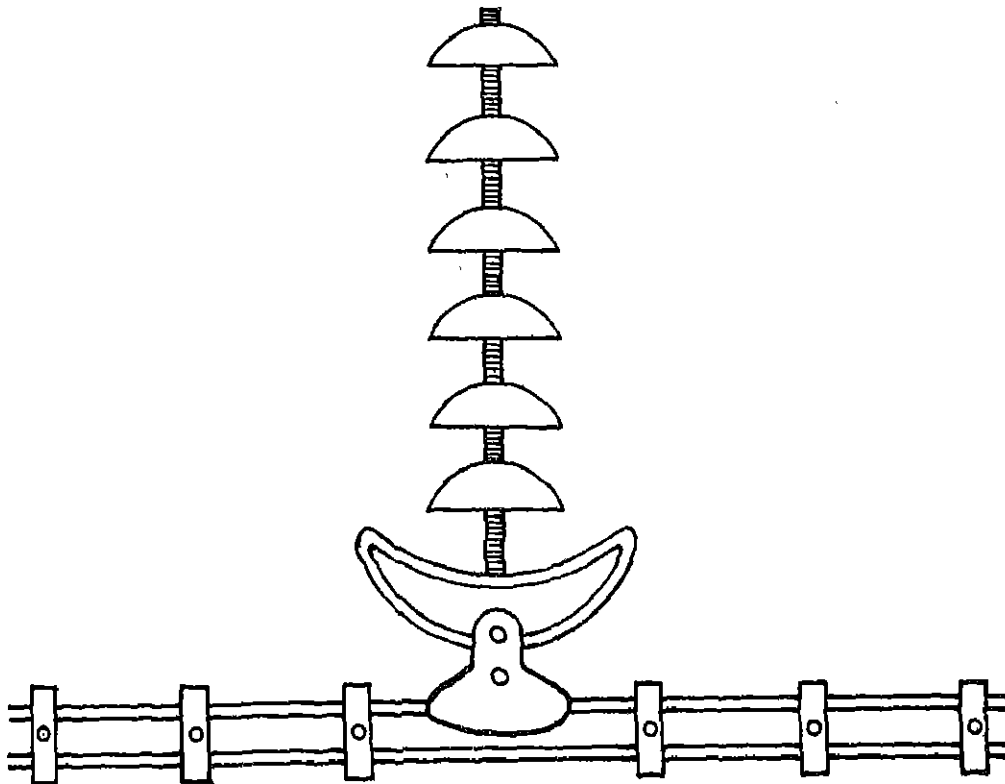


Fig. 9.2 Bates type parallel Wire Damper

- | | |
|---|---|
| tape. | in all the three conductors both ways. |
| (ix) Unscrew the damper clamp and slide it to the marked point. | (xiv) Keep yourself away from the line and disconnect the earthing rods and chains. |
| (x) If the clamp is loose, use more aluminium tape as packing. | (xv) Check the tools and materials, and bring down the same by the rope line. |
| (xi) Use spanners to tighten the damper clamps. | (xvi) See that no materials are left on the structure. |
| (xii) Use the same procedure to clamp down the damper on the other side of the insulator. | (xvii) Sign the line clearance form |
| (xiii) Complete the damper clamping | |

only when you are convinced that the work has been done properly.

- (iv) Sign the clearance form only after ascertaining that the work has been completed properly.

Precautions

- (i) Get the line clearance form filled and keep the key of the isolating switches in the safe custody of the Foreman.
- (ii) Ensure that the line is dead and earthed properly at the work site in addition to the end earths.
- (iii) Use the safety belt properly.

Questions

- (i) Why are dampers used in transmission lines?
- (ii) State the reasons for vibration in the lines?
- (iii) What are the safety procedures to be adopted while climbing up on the transmission towers?

ACTIVITY NO. 10

Binding Pin Insulators

Specific Objectives

The students will be able to:

- (i) identify the pin and insulators,
- (ii) bind the line conductor on the pin insulator.

Related Information

One of the most important and yet one of the most vulnerable links in transmission and distribution practice is undoubtedly the insulators. Porcelain and toughened glass are the materials principally used for supporting conductors on overhead lines. These materials are relatively brittle and inelastic.

Pin type insulators for the lower voltages are generally of the one-piece type, but at the higher voltages they are usually two or three pieces cemented together (Conductors are to be bound on the pin type insulators with the help of binding wire. For a particular conductor size, we have to select binding wire of a particular diameter.) These binding wires may be of tinned copper in the case

of copper conductors or aluminium in the case of AAC (All Aluminium Conductor) or ACSR (Aluminium Conductor Steel Reinforced) conductors. Shackle type insulators are bell-mouthed insulators used at all positions, either intermediate, terminal or angle. Where the angle exceeds 60° deviation, they are generally used in conjunction with shackle straps. They can be erected in either vertical or horizontal position.

Through these insulators, the weight of the conductors is transferred to the support, but the conductors should be kept electrically separated from the support.

Binding Wire Size

3.25 mm dia binding wire for conductors up to 5.03 mm dia.

4.12mm dia binding wire for conductor upto 7.14mm dia

5.18mm dia binding wire for conductor upto 14.3 mm dia

6.55mm dia binding wire for conductor upto 14.33 mm dia

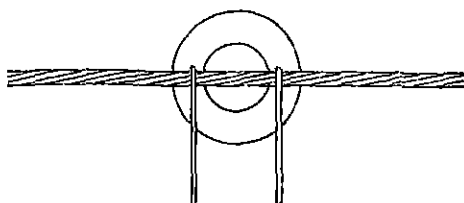


Fig.10.1(a) Bending of Wire



Fig.10(b) Wrapping of Wire

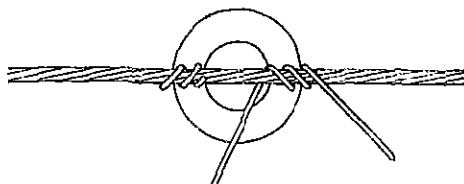


Fig.10.1(c) Tying Insulator

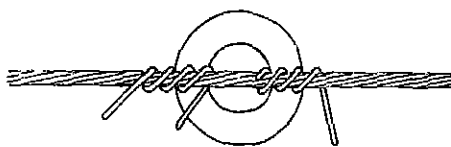


Fig.10.1(d) Wrapping Spirally

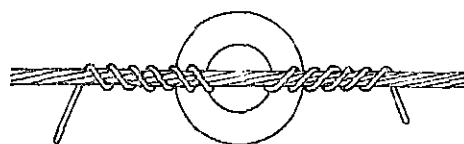


Fig. 10.1

Equipment and Materials

- (i) Ladder
- (ii) Safety belt
- (iii) Combination pliers/gas pliers
- (iv) Cutting pliers
- (v) Spanners
- (vi) Binding wire of suitable size.

Procedure

- (i) Mount the ladder against the pole and let the helper hold it in position.
- (ii) Fasten the safety belt around your waist.
- (iii) Climb up on the ladder and tie the safety belt on the cross arm
- (iv) Bend annealed tie wire of proper size and length around the insulator under the conductor forming a 'U' as shown in Fig. 10.1 (a). Both legs of tie wire should be of equal length after bending.
- (v) Hold the tie wire tight against the insulator through two tight close wraps around the conductor on each side of the insulator as shown in Fig. 10.1(b) keep these works snugly against the conductors.

- (vi) Cross the legs of the wire around the insulator, right to left and left to right as shown in Fig. 10.1(c).
- (vii) With the legs of the tie wire crossed, tightly wrap each leg spirally around the conductor at an angle of 45 degrees as shown in Fig. 10.1(d).
- (viii) Complete six spiral 45 degree wraps on each side of the insulator, bending back the ends and cutting them off short as shown in Fig. 10.1(e)
- (ix) Finish the joint by wrapping the ends properly and tightly as shown in Fig. 10.1(f).
- (x) Cut off the end with the help of pliers.
- (iii) Use sufficiently long binding wire for making the complete tie.
- (iv) Ensure secure binding between the live wire insulator and binding wire.
- (v) Binding should be done by hand. Do not use pliers.
- (vi) Avoid nicking the live wire.
- (vii) Do not use a binding wire which has been used previously.
- (viii) Use the safety belt for all overhead line work.

Precautions

- (i) Use only fully annealed binding wires.
- (ii) Use the correct size of binding wire according to the size of the conductor.

Questions

- (i) State the voltage range up to which pin insulators can be used in H.T. lines.
- (ii) What is the difference between hard drawn and annealed copper wires?
- (iii) Why should the binding be mechanically strong?

ACTIVITY NO. 11

Binding Shackle Insulators

Specific Objectives

- (i) To bind a shackle insulator to a through conductor.
- (ii) To bind a shackle insulator to the end of a conductor.

Related Information

Shackle insulators, shown in Fig. 11.1, are almost universally used on low voltage lines and provide a very neat, efficient and economical arrangement. They may be erected in either horizontal or vertical position, and the conductors are fixed in the grooves by means of soft copper or aluminium binders, as the case may be. In some instances, conductor wear has been experienced in exposed positions where the spindle is erected in a horizontal position. This wear is attributed to a "sawing" effect along the insulator when the conductor is ice-loaded. The insulators are bell-mouthed to prevent water being held in contact with the spindle. This type of insulator is used in all positions, either inter-

mediate, terminal or angle. Where the angle exceeds 60° deviation these insulators are generally used in conjunction with shackle straps.

Equipment and Materials

- (i) Cutting pliers 20 cm—2
- (ii) Mallet—1
- (iii) Foot rule—1
- (iv) Bench vice—1
- (v) H.D.B.C. 8 SWG—3 metres.
- (vi) Binding wire 14 SWG—6 metres.
- (vii) Sand paper 00—1 sheet
- (viii) Cotton waste
- (ix) Cotton thread

Procedure

(A) (For through conductor)

- (i) Take copper conductor of one metre length and straighten it with the mallet.
- (ii) Take the 14 SWG bare copper binding wire of 2 metres length and straighten it with the mallet.

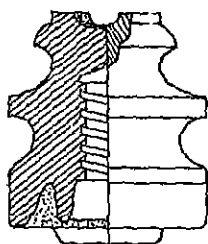
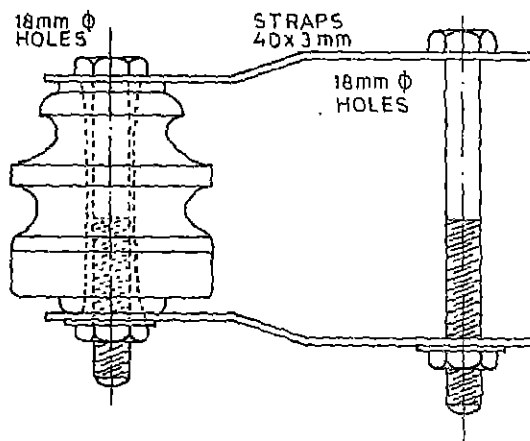


Fig. 11.1(a) Shackle Insulator

Fig. 11.1(b) L.T. Shackle Insulator
(Size 115 × 100) mm with fittings

- (iii) Clean both conductor and binding wire with the help of sand paper and cotton waste.
 - (iv) Tightly bind the binding wire on the conductor and give about 10 turns in one end.
 - (v) Place the conductor at the neck of the insulator as shown in Fig. 11.2(a).
 - (vi) Give one turn of the binding wire around the neck of the shackle insulator and through the main conductor. In the other hand, make one more turn.
 - (vii) Make one more loop tightly around the neck and the starting end of the main conductor. Then return the binding wire on the next end of the main conductor.
 - (viii) Tightly bind the binding wire on the other end of the conductor and give about 10 turns.
 - (ix) Cut off the excess binding wire.
 - (x) Press the ends of the binding wire with the main conductor with the help of the pliers.
- (B) (For end conductor)*
- (i) Take copper wire of two metre length and straighten it with the mallet.
 - (ii) Take 14 S^WG bare copper binding wire of 2 metres length and straighten it with the mallet.
 - (iii) Clean both conductor and binding wire with the help of sand paper and cotton waste.
 - (iv) Measure the periphery of the neck of the shackle insulator with the thread.
 - (v) Add allowance on both sides of that marking equal to the diameter of the wire.
 - (vi) Measure that length and mark equal to that length on the copper

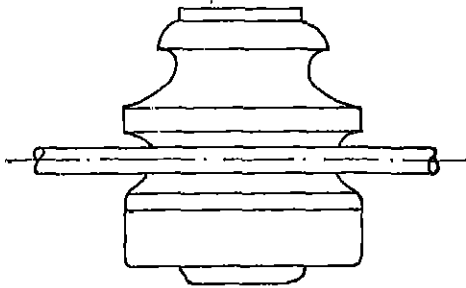


Fig. 11.2(a) Placing Conductor

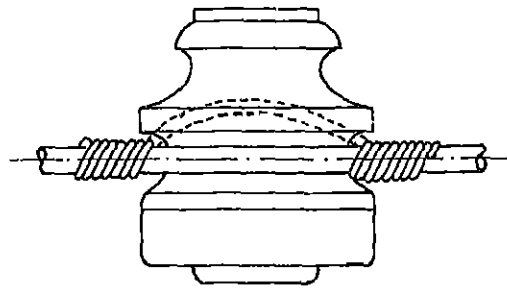


Fig. 11.2(b) Binding Conductor

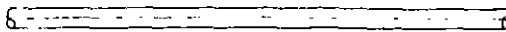


Fig. 11.3(a) Mains Conductor

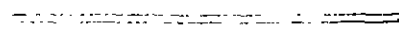


Fig. 11.3(b) Binding Wire

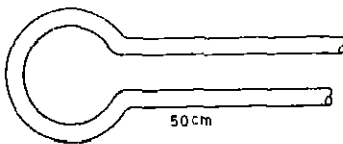


Fig. 11.3(c) Main Conductor Loop
conductor from a distance of 50
cms from one end.

- (vii) Make a loop as shown in Fig. 11.3(c) with the help of pliers.
- (viii) Place this eye on the neck of the insulator.
- (ix) Make a small bend on the main conductor as shown in Fig. 11.3(d). This loop will prevent the main conductor from pulling out.
- (x) Take bare copper binding wire and give one turn around the

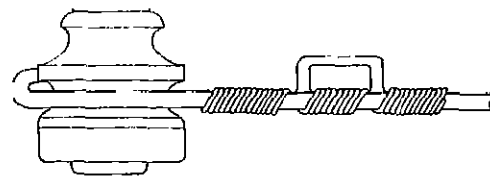


Fig. 11.3(d) Binding of Conductor

- neck of the insulator keeping one end of the binding wire along the main conductor up to 50 cms.
- (xi) Bind the binding wire tightly around the main conductors and the beginning end of the binding wire.
- (xii) Bind the binding wire after the small bend also and complete the binding by using both ends of the binding wire as shown in Fig. 11.3(d).

- (xiii) Cut off the excess binding wire.
- (xiv) Press the ends of the binding wire with the main conductor with the help of the pliers.
- (xv) Make sure that there is no gap between the turns of the binding wire.

Precautions

- (i) Be sure that the copper wire does not become soft due to too much malletting.
- (ii) Avoid nicks on the conductor.
- (iii) Inspect for cracks on the surface copper wires after bending.
- (iv) Binding of wire should be continuous and tight.
- (v) Avoid re-using binding wire.
- (vi) Use annealed copper wires as binding wire for copper conduc-

- (vii) Use binding wire of the same metal as that of the main conductor (Example: an aluminium conductor should be bound with aluminium binding wire only).

Questions

- (i) What is the purpose of a shackle insulator?
- (ii) Why is hard drawn copper wire unsuitable as binding wire?
- (iii) Why should the binding wire not be re-used?
- (iv) What is the purpose of the small bend in the main conductor?
- (v) How can a hard drawn copper wire be annealed?
- (vi) Why should nicked or cracked conductors not be used in the line?

ACTIVITY NO. 12

Clamping of Disc Insulators

Specific Objective

The students will be able to clamp the suspension disc insulator and make a bill of material.

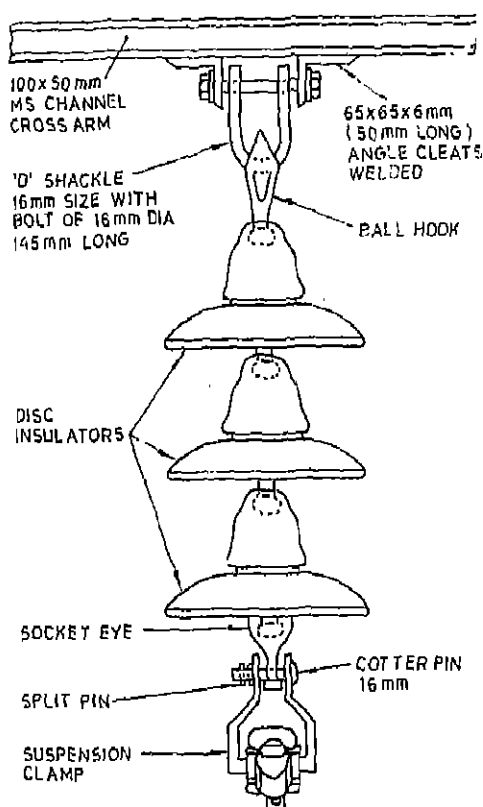


Fig. 12.1 Suspension Insulator String

Related Information

For the purpose of insulating O/H line for 33 KV and above, suspension insulators are used. Each unit is rated at 11 KV. For insulating O/H lines of 33 KV 2 to 3 units of suspension insulators are used:

66 KV 4 to 5 units of suspension insulators are used:

132 KV 8 to 10 units of suspension insulators are used:

220 KV 13 to 16 units of suspension insulators are used:

409 KV 22 to 25 units of suspension insulators are used:

Suspension Insulator string is shown in Fig.12.1

Equipment and Materials

Insulator

- | | |
|--------------------------------------|-----|
| (i) D-shackle with best | one |
| (ii) Ball hook | one |
| (iii) Ball and socket type insulator | one |
| (iv) Socket eye | one |
| (v) Suspension clamp | one |

- | | |
|------------------------|-----|
| (vi) 16 mm. copper pin | one |
| (vii) Split pin | one |
| (viii) Plain washer | one |
| (ix) Security clip | two |

Procedure

- (i) The ball hook should be fitted with the D-shackle.
- (ii) The ball hook is fixed on the socket of a disc insulator.
- (iii) After fixing of the ball in this insulator socket, insert the W-security clip into the space left in the socket below the ball. This will keep the ball secured in the socket, preventing the ball from slipping out.
- (iv) Fix the other insulators of the string in the same manner.
- (v) At the bottom of the lowest insulator, fix the socket eye.

- (vi) Fit the suspension clamp on the socket eye by means of a cotter pin. The cotter pin will be locked with help of a split pin.
- (vii) Check the whole assembly for its flexibility.
- (viii) Mount the assembly on the cross arm channel clamp provided for the insulator string.

Precautions

- (i) The minimum failing load of the insulators and their fittings shall be 7000 Kg.
- (ii) The fitting shall be suitable for 48 mm² to 65 mm² ACSR.

Questions

- (i) Where are the suspension insulators used?
- (ii) Draw the suspension insulators for a 66 KV line?

ACTIVITY NO. 13

To Clean the Pin and Disc Insulator

Specific Objectives

- (i) To develop skills for visual inspection of insulators.
- (ii) To develop skills in cleaning insulators.

Related Information

Insulators form a vital accessory in the transmission/distribution lines to insulate the main supply lines from supports. They are made of glass or porcelain. Though these materials are brittle and non-elastic, they may develop cracks due to stress and strain. Further, air pollution may deposit dust or chemicals on the surface of the insulators which in turn may decrease the insulating properties of the insulator resulting in flashover. If a flashover occurs, the power to the consumers cannot be despatched till the cause of the flashover is removed. Moreover, such flashovers may result in complete breakdown of the insulation. Hence, it is necessary that the insulators be inspected periodically and maintained by way of

cleaning in places where industrial chemical air pollution is high. This process of cleaning of insulators is also known as line washing.

In some cases, even in remote places, the insulators may be subjected to flashover due to birds and animals which may sit near or on the insulator. Lightning is another cause for the damage of insulators, when a clipped or cracked insulator is found it has to be replaced.

Equipment and Materials

- (i) Safety belt
- (ii) Earthing rod with brass chain
- (iii) Cotton rag
- (iv) Clear water
- (v) Carbon tetrachloride-650 ml.-two bottles.

Procedure

- (i) Make sure that the line is disconnected and line clearance is taken through line clearance forms.
- (ii) Visually inspect the insulators

and ascertain which insulators need cleaning.

- (iii) Fasten the safety belt around your waist.
- (iv) Climb up the tower and position yourself near the insulator cross arm
- (v) Fix one end of the safety belt to the cross arm.
- (vi) Use earthing chains and earthing rod and earth the line.
- (vii) Use the wet cotton rag and clean the insulators.
- (viii) If the dirt is of carbon base, use cloth dampened with C.T.C. (carbon tetra-chloride) to clean the insulators.
- (ix) Clean the insulators till the polished/glazed surface of the insulator is visible both on the top as well as bottom sides.
- (x) After completion of the work, collect all the materials, remove the earth chains and earth rod and climb down.
- (xi) Make sure that no materials or tools are left on the cross arm insulator or line.

Precautions

- (i) Get the clearance form filled and keep the key of isolating switches in the safe custody of the Foreman.
- (ii) Ensure that the line is dead, completely isolated and earthed at the ends.
- (iii) Earth the line locally on the pole of working.
- (iv) Use the safety belt.
- (v) Sign the clearance form only when you are convinced that the work has been completed properly.

Questions

- (i) What will happen if the insulator is unclean?
- (ii) What are the main sources of dirt and dust?
- (iii) State the procedure to be adopted before climbing up on the poles?
- (iv) Why should CTC be used for cleaning insulators?

Tabulation Record and Observations

<i>Tower No.</i>	<i>Insulator position/phase</i>	<i>Condition</i>	<i>Method adopted</i>	<i>Remarks</i>
Example AC 203	Insulators of red, blue, yellow phase.	Carbon deposit & dirt	Cleaned with CTC	X

ACTIVITY NO. 14

Replacement of a Damaged Insulator

Specific Objective

To familiarize with the techniques for changing various types of damaged insulators on dead lines.

- (A) Pin insulators
- (B) Suspension insulators
- (C) Strain insulators

Related Information

Insulator failure sometimes occurs due to abnormal over voltages appearing on the line. It is essential to change these damaged insulators in order to maintain continuity of service.

Equipment and Materials

- (i) Insulators: pin type, suspension type and strain type
- (ii) Come-along clamp
- (iii) Suspension clamp
- (iv) Ropes
- (v) Spanners
- (vi) Wrenches

Procedures

There are three types of insulators used in transmission systems:

- (A) *Replacement of pin insulators*
 - (a) The faulty section has to be made dead from the sub-station and both sides of the section should be properly earthed.
 - (b) The lineman will climb up and untie the bound conductor from the insulator and the conductor is allowed to stay on the cross arm or side arm.
 - (c) The damaged insulator is replaced by a new insulator.
 - (d) The conductor is tied with binding wires.
 - (e) The lineman will then climb down and remove the earthing and give clearance to the sub-station for energizing.

(B) *Replacement of suspension insulators*

- (a) The faulty section has to be made dead from the sub-station and both sides of the section should be properly earthed.
- (b) The lineman will climb up and clamp the conductor near the damaged insulator with some other suspension clamp. This clamp is to be tied to the side arm firmly with a rope so that the damaged insulator is free from tension.
- (c) The suspension clamp of the insulator string is opened and the conductor is removed from it.
- (d) The damaged discs are replaced by new ones.
- (e) The conductor is again clamped to the suspension insulator.
- (f) The other suspension clamp is opened and untied from the side arm and removed.
- (g) The lineman will then come down and remove the earthing and give clearance to the sub-station.

(C) *Replacing strain insulators*

- (a) The faulty section has to be made dead from the sub-station and both sides should be properly earthed.
- (b) The lineman will climb up

and clamp the conductor with a come-along clamp to the pole/tower to keep proper tension of the conductor. This also makes the damaged insulator free from tension.

- (c) The clamp of the damaged insulator is opened and the damaged discs are replaced by new ones.
- (d) The conductor is again clamped to the strain insulator.
- (e) The come-along clamp is made free.
- (f) The lineman will then come down and remove the earthing and give clearance to the sub-station.

Precautions

- (i) Before climbing the tower, the lineman should ensure that the line is dead and earthed properly.
- (ii) Before giving clearance to the sub-station, he should ensure that
 - (a) no tools are left on the tower/pole; and
 - (b) the earthings are removed.

Questions

- (i) Why do insulators fail?
- (ii) How do you replace a pin insulator?
- (iii) How do you replace a strain insulator?
- (iv) Why is it necessary to ensure that earthing is properly done before carrying out the work?

ACTIVITY NO.15

Field Testing of Line Insulators by a Megger

Specific Objective

To measure the insulation resistance of an overhead suspension line insulator on a dead line and to check whether the insulator is faulty or not.

Related Information

Measurement of resistance by a megger requires the shutting down of the line during the test. A megger testing set consists of a hand-driven direct current generator and a direct reading ohmmeter mounted in a box.

The megger test comprises measuring the insulation resistance of each individual insulator on the line. A good insulator has a very high insulation resistance. A faulty or defective insulator, on the other hand, has a very low insulation resistance compared to that of a sound one. A defect in an insulator is usually caused by cracks in the porcelain.

To apply the test, the two leads from the megger are connected to the two sides of the overhead line insulator. In the case of the cemented type suspension insul-

ators, one lead is connected to the cap and the other to the pin. A megger fork is often used to facilitate making these connections from the pole or tower. This fork has two metal tines which are rigidly supported and insulated from each other. The tines are 25 to 50 cms long and spaced about 12-15 cms apart. Insulated leads should be attached to the tines and these should be sufficiently long to reach from the top of the highest tower to the megger on the ground.

If the insulation resistance is low (usually less than 500 mega-ohms), the insulator is taken to be defective and should be replaced.

Equipment and Materials

<i>Sl. No.</i>	<i>Item</i>	<i>Range or rating</i>	<i>Quantity</i>
(i)	Megger	1 KV or 5 KV	1
(ii)	Insulated leads		Required length
(iii)	Earthing rods		Required number

Procedure*Tabular record*

- (i) The line under study is disconnected from the source.

- (ii) The line is grounded at as many points as possible before beginning work. This is accomplished by connecting the ground line to the steel tower or ground before attaching it to the line and then attaching the other end of the ground line to the line conductor by means of a hook or clamp on end of a dry wooden stick (earthing rod).

- (iii) Choose the suspension insulators to be tested and place one tine of the megger for on the fittings on each side of the top unit of the string. Twist to ensure a good contact between the fork tines and the fittings.

- (iv) With the form leads connected to the earth and line terminals of the megger testing set, obtains the reading of the insulation resistance of the unit. If the reading is infinity, it is in a very good condition.

- (v) Test the other units of the suspension unit in a similar manner.

- (vi) Remove the megger fork.

- (vii) Remove the ground connection from the line and then from the tower.

Sl. No.	Unit No. from top	Insulation resistance	Does it require to be changed
---------	-------------------	-----------------------	-------------------------------

- (i)
(ii)
(iii)
(iv)

Precautions

- (i) Do not use a megger on an insulator unless the ground circuit is connected. This connection removes any static charge that may be left on the line conductor.
- (ii) During humid weather, megger tests, should be made late in the day or when the temperature falls. This avoids surface leakage.

Questions

- (i) What is to be done if one unit of a suspension insulator has a low insulation resistance?
- (ii) Why is the line to be earthed before carrying out the test?

Note

This experiment should be conducted in collaboration with a substation authority when the latter takes a shutdown of a line for maintenance.

ACTIVITY NO. 16

Guarding Overhead Lines

Specific Objectives

The students will be familiarized with:

- (i) the necessity of guarding,
- (ii) the techniques of different types of guarding.

Related Information

When a conductor is snapped, it falls on the ground. If the line is run across a road/railway crossing or through a populated area, the snapped line, before falling on the ground, may touch a person and cause an accident. In order to avoid such accidents, guarding is provided on the line.

In L.T. lines, loop guarding is provided when the line is run along the road. But in the case of a road/railway crossing, cradle guarding is provided. In H.T. lines also cradle guarding is used.

When a power line crosses a communication line, it is necessary to provide cradle guarding.

Cradle guarding and loop guarding are shown in Figs. 16.1 and 16.2 respec-

tively.

Rule 88 of the Indian Electricity Rules should be consulted for guarding overhead lines.

Equipment and Materials

- (i) Bolts and nuts
- (ii) 10 SWG GI wire
- (iii) Split insulator
- (iv) Binding wire.
- (v) Lineman's tool kit

Procedure

Cradle guarding is done on road/railway crossings. For cradle guarding as shown in Fig. 16.1:

- (i) Cut the cross lacings to size.
- (ii) Cut the guard wire to size.
- (iii) Fix the guard wire on the cross arm with the bolts and nuts.
- (iv) Fix the cross lacings on the guard wire with binding wire.

For loop guarding:

Loop guarding is done on L.T. 3-phase,

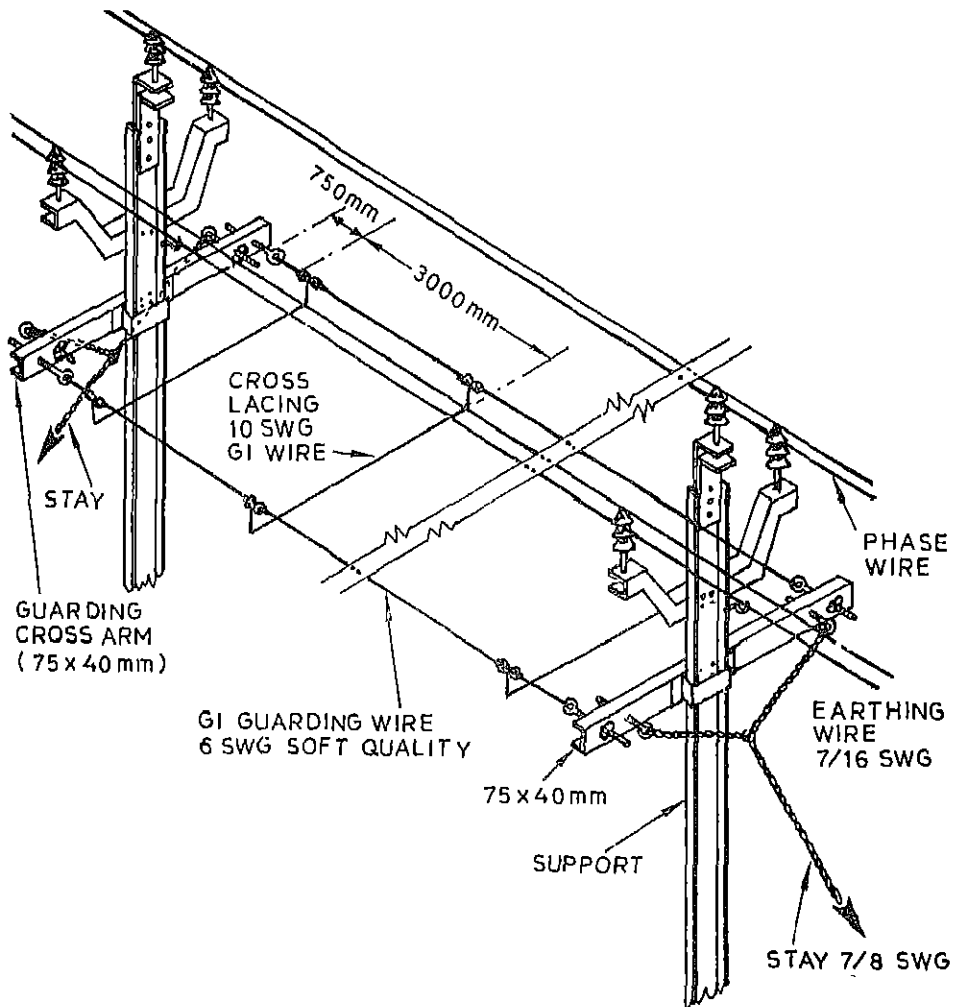


Fig. 16.1 Cradle Guarding

4-wire lines.

- (i) Cut the loop wire to size.
- (ii) Make binding with the split insulator with the top-most phase wire.
- (iii) Bind the bottom of the loop and the neutral with binding wire.

Questions

- (i) Specify the wire used for cross lacing of cradle guarding.
- (ii) Draw a sketch of a split insulator. Where is it used?

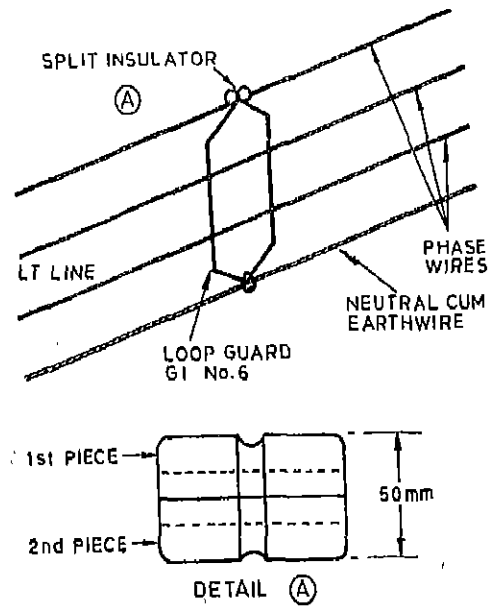


Fig. 16.2 Loop Guarding

ACTIVITY NO. 17

To Make Twist Sleeve Joints for All Aluminium Conductors

Specific Objectives

- (i) To prepare the conductors for jointing.
- (ii) To make a twist sleeve joint.

Related Information

The best way to make a joint in a medium size line conductor is by means of the so-called "splicing sleeve". This is a special connection that ensures good electrical and mechanical joints. The sleeve itself is a piece of single or double tubing. The tubing may be either split or seamless. To make a sleeve joint, the ends of the wires should be scrapped clean and bright. They are then inserted, one in each tube, if a double tube is used, from opposite ends, so that they lie side by side. The ends of the wires should project several inches beyond the ends of the sleeve. The projecting wires are sometimes given a sharp bend to keep them from slipping out of the sleeve. The ends of the sleeves are then grasped by two sleeve clamps or twisters.

The conductor manufacturer gives the sleeve number to be used for a particular line conductor. Sleeves should always be made of the same kind of material as the conductor. If the line is a copper line, either hard or soft drawn, the sleeves should always be made of soft drawn copper. If the conductors are of aluminium, the sleeves should be made of aluminium. In making sleeve joints in iron wires, the sleeve should be of tinned iron.

Equipment and Materials

- (i) All aluminium conductor-4 metres
- (ii) Aluminium sleeve- three
- (iii) Cutting pliers 20 cms-one
- (iv) Sleeve clamps or twisters-Two
- (v) Petrol
- (vi) Cotton cloth

Procedure

(A) for single sleeve Joints

- (i) Cut the ends of the line conduc-

- tor neatly at the ends.
- (ii) Clean the conductor with the help of petrol.
 - (iii) Check whether the sleeve interior is clean.
 - (iv) Insert the ends of the line conductor from opposite ends.
 - (v) Let the conductor protrude about 8cms outside the sleeve ends.
 - (vi) Use the pliers and make a sharp bend in the conductor ends.
 - (vii) Check the die number and sleeve number and insert the sleeve inside the correct die of the twisters. Fig 17.1 shows the various twisters used for this purpose.
 - (viii) Hold the sleeve at the ends by the two twisters and give three or four turns simultaneously by turning the twisters in opposite directions. The finished twist sleeve joint should look as shown in Fig 17.2.
 - (ix) Remove the twisters by unlocking the dies.

(B) For Double Sleeve Joints

- (i) Cut the two ends of the conductor neatly.
- (ii) Clean the conductor with the help of petrol.
- (iii) Insert the conductors through both the sleeve as shown in Fig 17.3.1. i.e. inserting through opposite ends of the sleeves.
- (iv) Give a sharp bend at the end of each conductor so that the conductor will not slip out.
- (v) Make three and a half turns with the sleeve twisters-one on each end and twist tightly. The completed joint will look as shown in Fig. 17.4.
- (vi) Remove the twisters.
- (vii) Cut off the ends and the joint is completed.

Precautions

- (i) Use the sleeve of the same metal as the conductor.
- (ii) Use the die number as recommended by the conductor manufacturer.
- (iii) Sharp bends in the end of the conductor are essential to avoid slips.
- (iv) Avoid twisting more than necessary.
- (v) Avoid nicks on the conductor.

Questions

- (i) Why should the conductors be cleaned ?
- (ii) Why should the correct size dies be used ?
- (iii) What will happen if the joint is twisted too much ?

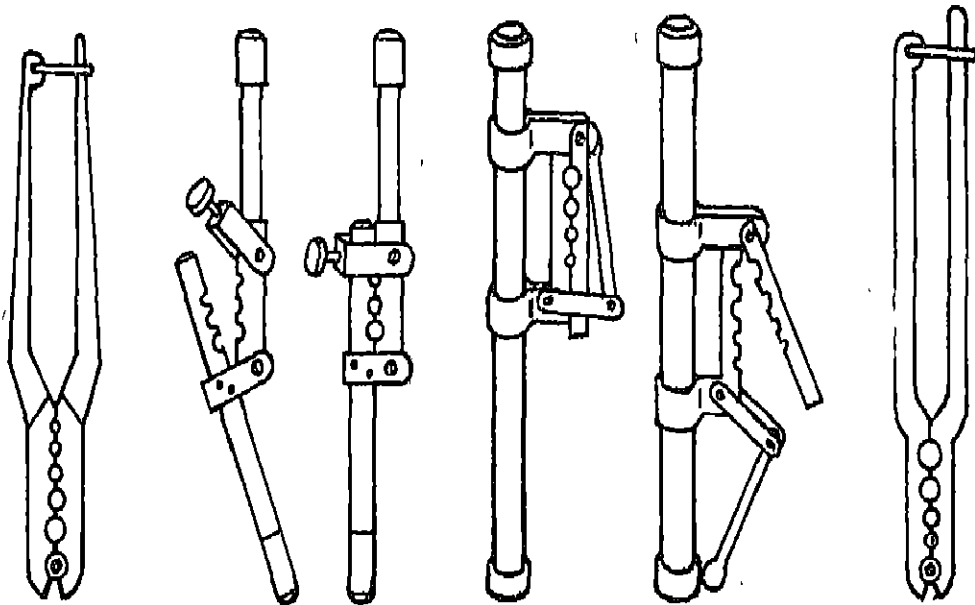


Fig. 17.1 Twisters

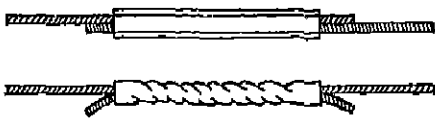


Fig.17.2 Twist Sleeve Joint

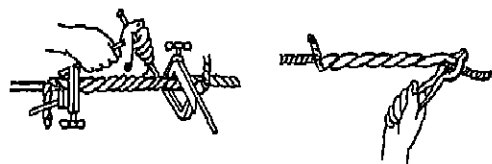


Fig.17.3.2 Twisting Sleeves



Fig.17.3.1 Inserting Conductors to Sleeves

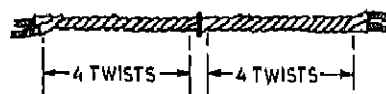


Fig.17.4 Double Sleeve Joint

ACTIVITY NO. 18

To Make Compression Sleeve Joints for ACSR Conductors

Specific Objectives

- (i) To prepare the conductors for jointing.
- (ii) to make compression sleeve joints.

Related Information

ACSR conductors are joined together with the help of compression sleeve joints which are found to be much more reliable than thin-walled sleeve joints which are twisted. A *compression joint* also makes use of a sleeve which is thick-walled. Instead of twisting the sleeve, however, the sleeve is compressed with great force on to the conductor. The use of a die in compression makes the sleeve grip the conductor firmly.

There are three types of tools available for making the compression joints. They are :

- (i) Hand operated compression tool (Fig. 18.1)

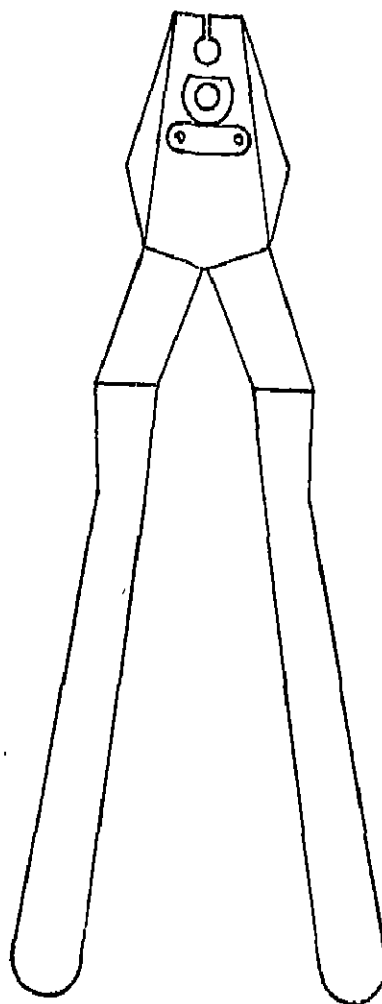


Fig. 18.1 Hand operated Compression Tool

- (ii) Hand operated hydraulic press compression tool (Fig. 18.2)

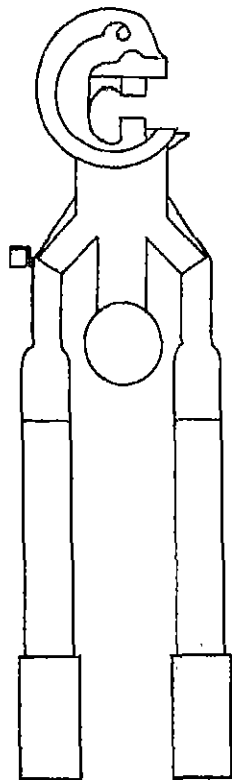


Fig. 18.2 Hand operated Hydraulic Compression Tool Press

- (iii) Compression tool operated by foot, electric or pneudraulic power pump (Fig. 18.3)

After compression the splices should be in straight alignment with the conductor to avoid stresses in the wire at the ends of the sleeves. When compression tools are out of alignment, the compression sleeves will bow or curve during the

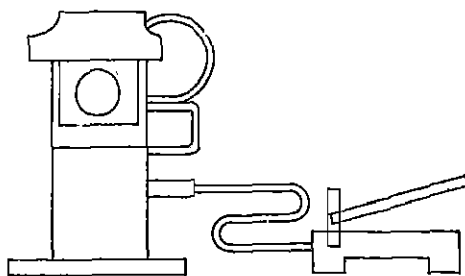


Fig. 18.3 Compression Tool Operated by Foot (Electric or Pneudraulic Power Pump)

compression operation.

Such sleeves should be straightened before the joint is placed in service. To avoid corrosion and to have good electrical conductivity, conducting grease is used inside the sleeves. This procedure is for institutional practice. In case the joints need to be done on transmission lines, the usual safety practices should be followed, as stated in twist sleeve joints.

Equipment and Materials

- (i) Hand-operated compression tool-one
- (i) Aluminium conductor steel reinforced (ACSR)
- (iii) Thick walled compression sleeve/one set (Both steel and aluminium)
- (iv) Conducting grease (KER-AL-LITE) - 150 grams
- (v) Petrol-1/2 litre
- (vi) Hacksaw with blade-one
- (vii) Hammer ball pein/4kg-one

Procedure

- (i) Clean the conductor ends thoroughly. All dirt and grease should be removed with gasoline or similar cleaning solvent.
When a conductor that has been in service is being spliced, special care should be taken to remove oxidation in that portion which is inserted in the sleeve
- (ii) Match the size of the splicing sleeve to the size of the conductor.
- (iii) The die number must be matched to the sleeve number.
- (iv) The conductor ends must be properly centred in the sleeve.
- (v) Check whether the sleeves interior is perfectly clean.
- (vi) Slip the aluminium compression sleeve over one cable and back it out of the way along the cable.
- (vii) Using the hacksaw, cut off the aluminium strands from each cable, exposing the steel core for a distance of a little more than half the length of the steel compression sleeve. Be careful not to nick the steel core with the saw.
- (viii) Insert the steel core ends into the steel compression sleeve, making sure that the ends are jammed against the step in the middle of the sleeve as shown in Fig 18.4(c).
- (ix) Compress the steel sleeve over its entire length, making the first compression at the centre and

working out toward the ends, allowing the dies always to overlap their previous position.

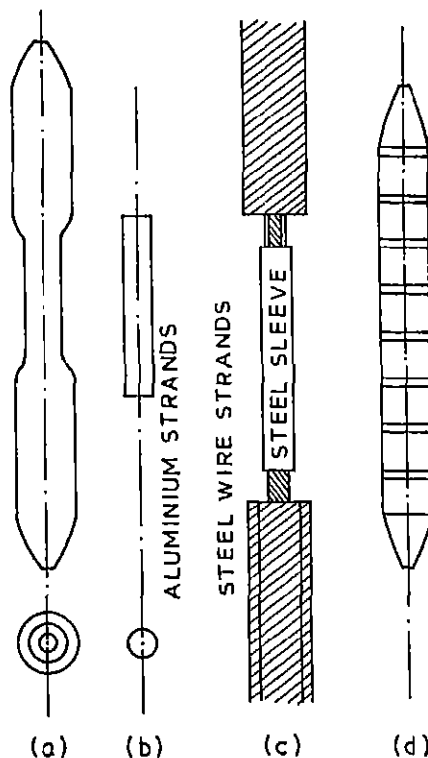


Fig. 18.4 Compression type Splicing Sleeve

- (x) Remove the die from the conductor and measure from the centre of the steel joint, the distance of one-half the length of the aluminium sleeve and mark the cable with tape. This will centre the aluminium sleeve when slipped over the steel joint.
- (xi) Slip the aluminium sleeve up

over the steel joint to the tape mark. This will centre the aluminium sleeve over the steel joint.

- (xii) Using the gun equipped with the tapered nozzle provided with the compressor, inject filler paste (Kar-Al-Lite) through both holes provided in the aluminium sleeve.
- (xiii) Insert the plugs in the filler holes and hammer them firmly in place. They will be securely locked in compressing the aluminium joint.
- (xiv) Finally, compress the aluminium sleeve starting from the centre. Make the inner edges of the dies matching the position stencilled on the aluminium sleeve. Make additional compressions advancing to the ends, allowing the dies always to overlap the previous portion, as shown in Fig. 18.4 (d)

Precautions

- (i) Ensure that the conductor parts to be inserted inside the sleeves are thoroughly cleaned with petrol.
- (ii) Avoid nicks on the conductors.
- (iii) Make the number of indent/compressions as specified by the conductor manufacturer.
- (iv) Use the correct number dies.

Questions

- (i) Why and where are compression sleeve joints preferred to twist sleeve joints ?
- (ii) Why is conducting grease used in the sleeves ?
- (iii) What will happen if the compression joint is not straight ?
- (iv) What are the precautions to be observed while doing compression joints ?

ACTIVITY NO. 19

Preparation of an Earth Pit

Specific Objectives

The students should be able to:

- (i) prepare an earth pit for making earth connection of electrical equipment;
- (ii) prepare a list of materials for earthing;
- (iii) explain the necessity of earthing.

Related Information

Earthing of equipment is very important in a substation for the purpose of safety of the equipment and the personnel working on it. Earthing wire is connected to an earth electrode. The earthing system should have very low resistance. In electrical installations, the following components must be earthed :

- (i) the frames, tanks and enclosures of electric machines, transformers and apparatus;
- (ii) the operating mechanism of switch gear;
- (iii) the frame of switch boards, control boards, individual panels; and

- (iv) structural metal parts of indoor and outdoor sub-stations, metal cable jointing boxes, steel poles and towers, details of an earth pit as shown in Fig 19.1.

Equipment and Materials

- (i) Copper or GI plate.
- (ii) Bolts, nuts, check nuts of copper or GI.
- (iii) Cement concrete, bricks and masonry material.
- (iv) Iron mesh
- (v) Funnel
- (vi) Charcoal and salt
- (vii) GI pipe

Procedure

- (i) The earth pit should be dug as per the drawing.
- (ii) In plate earthing an earthing plate either of copper or of G.I is buried into the ground with its face vertical, at a depth not less

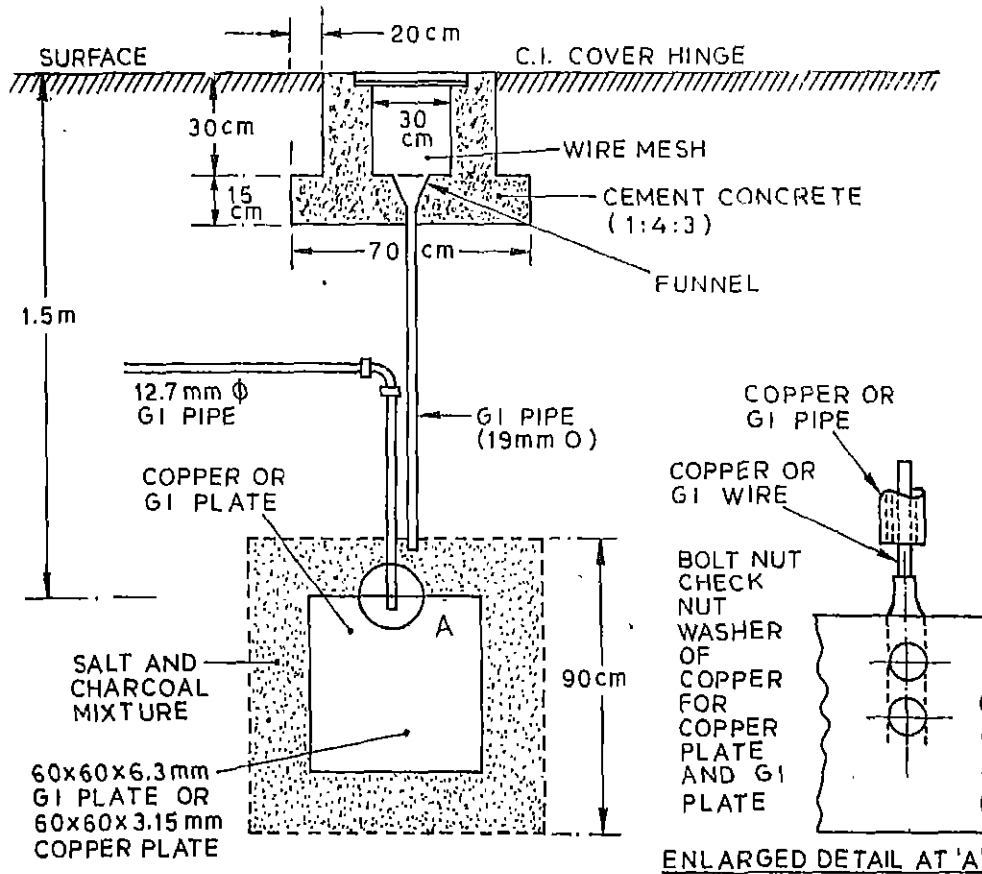


Fig. 19.1 Details of an Earth Pit

- than 1.5 m. from the ground level.
- (iii) The earth plate is embedded in alternate layers of coke and salt for a minimum thickness of 15 cms. The earth wire is securely bolted to an earth plate with the help of a bolt, nut and washer made of the same material that the earth plate is made of.
 - (iv) A small masonry brick wall enclosure with a cast iron cover on top for carrying out periodical inspection should be made.
 - (v) In the summer season moisture in the soil decreases causing an increase in earth resistance. The cement concrete work enables pouring of water to keep the soil

moist.

- (vi) The earth wire is carried in a G.I. pipe, at a depth of about 60 cms. from the ground level, for connection.

the soil surroundings the earth plate permanently moist.

Questions

- (i) How many types of earthing are there ?
- (ii) Draw the details of an earth pit.
- (iii) Why is earthing of electrical equipment necessary ?

Precautions

Three or four buckets of water should be poured into the pit every few days to keep

Measurement of Earth-Electrode Resistance

Specific Objectives

- (i) To measure the resistance of an earth electrode.
- (ii) To ensure an effective earthed connection.

Related Information

From the point of view of safety of personnel the metal parts of equipment/enclosure must be properly earthed. Under certain circumstances, the accessible metal parts of different electrical equipment may acquire enough potentials with respect to earth to cause a shock to the personnel working on it. This electrical shock can be fatal. If the metal parts are earthed properly, the possibility of shocks to the personnel may be avoided.

Earthing is usually done by connecting an earth wire or strip between the equipment, body/enclosure and the earthing electrode. The earthing electrode should provide low resistance. In the event of a fault, the equipment, body/enclosure will not acquire enough poten-

tial to cause a shock.

The earth electrode resistance measurement can be carried out by the ammeter-voltmeter method, in accordance with the circuit diagram given in Fig. 20.1. This method employs A.C. supply. But, it is not preferred due to the polarization effects.

The earth electrode resistance will be given by,

$$R = V/I \text{ } \Omega$$

Where V is the voltage between electrodes X and Z , I is the current through the electrode X .

Procedure

- (i) Hammer down three electrodes, X , Y and Z , in a straight line in soil which is not too rocky. The distances XZ and ZY should be equal.
- (ii) Make the electrical connections as shown in the circuit diagram. (Fig. 20.1)
- (iii) Adjust the variac so that the

output is minimum.

- (iv) Switch on the main supply. Adjust the variac and rheostat to get a current of approximately 0.5 A. The Variac output should never exceed 50 V.
- (v) Note down voltmeter and ammeter readings and switch off the supply. Calculate the earth electrode resistance.
- (vi) Change the positions of X and Y by at least 6 meter away from Z and repeat steps (i) to (iv).
- (vii) Repeat steps (i) to (vi) till the value of earth electrode resistance as calculated in step (v) remains substantially constant. This will be the required earth electrode resistance.

Precautions

- (i) Before switching on the supply, ensure that rheostat has been kept in the position of maximum resistance and the variac has been adjusted in the position of minimum output.
- (ii) The electrodes should be moved at equal distance from Z in both directions.
- (iii) Do not touch the electrodes while the supply is on.

Questions

- (i) What is the necessity of effective earthing ?
- (ii) Why is it necessary to measure the resistance of earth electrodes.

Equipment and Materials

<i>S.No.</i>	<i>Item</i>	<i>Range or Rating</i>	<i>Nos.</i>
i)	Single phase variac	230V, 50HZ/1A	1
ii)	Ammeter (dynamometer type)	0-500 ma a.c.	1
iii)	Voltmeter (dynamometer type)	0-50V	1
iv)	Rheostat	0.5A 100 ohms	1
v)	Connecting wires		
vi)	Electrodes (G.I.)	1/2 m	3
vii)	Hammer		1

Tabular Record

S.No.	Distance XZ	Voltmeter Reading	Ammeter Reading	Earth Resistance	Remarks
(i)					
(ii)					
(iii)					
(iv)					
(v)					
(vi)					
(vii)					

Earth electrode resistance, $R =$

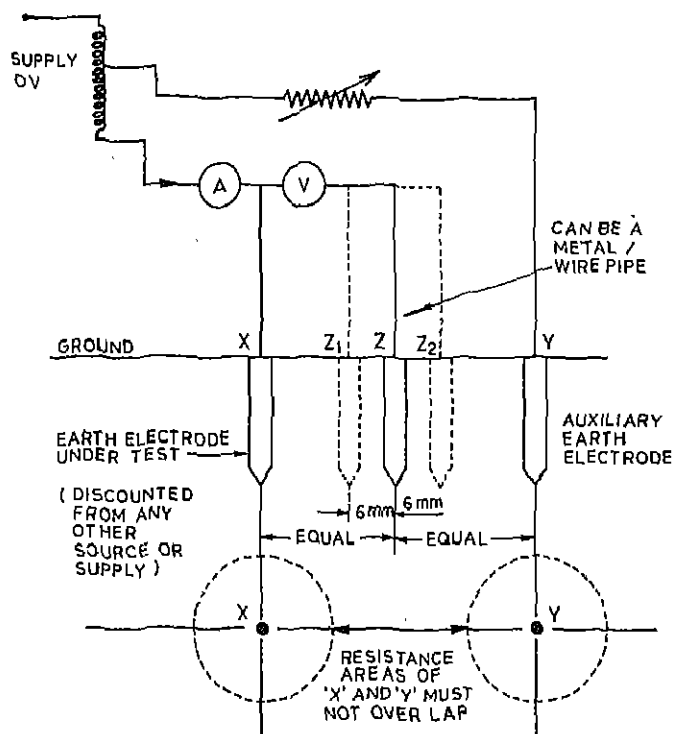


Fig. 20.1 Measurement of Earth Electrode Resistance

ACTIVITY NO. 21

Checking Earth Continuity Conductor Resistance

Specific Objectives

To acquaint the students with the necessity of having a very low resistance of the earth continuity conductor and to check that the same is less than two ohms.

Related Information

All metal parts of electrical equipments and enclosures should be properly earthed for the safety of the personnel working.

Under certain circumstances, the metal parts of equipment may attain a potential difference with respect to the earth. If a person standing on earth comes in contact with such metal parts, current will flow through him, depending upon the potential of the metal part. This current will cause the person to experience a shock and if the potential is high enough, the shock may be fatal.

Hence, it is absolutely necessary that metal parts of electrical equipment, under no condition should be allowed to attain

any potential with respect to earth. This is ensured by electrically connecting these metal parts to the earth. It is necessary, therefore, that this connecting conductor, known as the earth continuity conductor should have as low a resistance as possible. The resistance of the earth continuity conductor from any point to the earthing must be less than two ohms.

With the help of the circuit diagram shown in Fig. 21.1 it is possible to check whether the resistance of the earth continuity conductor is less than the above specified value or not.

In case the ammeter reading, when the battery is connected through the earth continuity conductor to the earth electrode, is equal to or greater than that when the battery is connected to the earth electrode through the two ohms resistor, the resistance of the earth continuity conductor is within the limit of two ohms.

Equipment and Materials

S.No	Item	Range of Rating	Number
(i)	Battery	6V	1
(ii)	Ammeter	0-10 A	1
(iii)	Rheostat wire	2 ohms 5 amps.	1
(iv)	One-way key	-	2
(v)	Two-way key	-	1
(vi)	flexible connecting wire	-	-

Procedure

- (i) Connect the circuit as shown in Fig. 24.1
- (ii) Close one-way key K_3 .
- (iii) Close the one-way key K_1 and put K_2 in position 1. Record the ammeter reading.
- (iv) Open key K_1 and put K_2 in position 2. Record the ammeter reading.
- (v) Open key K_3 .

Tabular Record of Observations

S.No	Conditions of key K_1	Position of K_2	Ammeter Reading	Resistance of earth continuity conductor less than 2 ohms.

Precautions

- (i) The battery should be fully charged.
- (ii) Key K_3 should be closed for the minimum possible time.
- (iii) The ammeter readings should be noted very carefully.

Questions

- (i) Why should the earth continuity conductor resistance be very low?
- (ii) In case the earth continuity conductor resistance is more than two ohms, what is to be done?

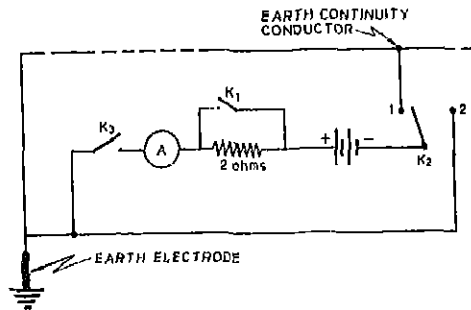


Fig. 21.1 Circuit diagram for checking Earth Continuity Conductor Resistance.

ACTIVITY NO. 22

Measurement of Earth Resistivity

Specific Objective

To measure resistivity of earth (four-point-method).

Related Information

The resistance of the soil will affect the effective earthing of electrical equipment. The lower the resistivity of the soil, the more effective could be the earthing. If the soil is of higher resistivity, an earthing pit would have to be treated with other materials (like salt, calcium chloride copper sulphate, etc.) which would give the requisite low earth electrode resistance. Before one is able to decide on the treatment that the earthing pit is to be given, the measurement of the soil resistivity has to be carried out. The measurement of soil resistivity also has to be carried for location of various electrical installations like transmission towers, sub-stations etc.

The resistivity of earth varies depending upon the composition of soil, temperature, moisture content, etc. Rocky soil has higher resistivity than clayey soil.

The earth resistivity will be lower in the monsoon season than in other seasons because of higher water content.

The earth resistivity is usually measured with the help of an earth resistivity meter or a megger. The method employed can be the four-point method in which four electrodes are driven into the ground at an equal distance of 'a' cm. as shown in Fig 22.1. The depth of the driven electrodes must not exceed one-twentieth of

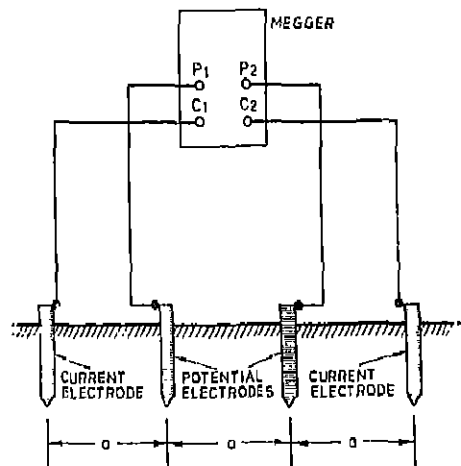


Fig. 22.1 Circuit diagram for Measurement for Earth Resistivity

'a'. The two outer terminals are connected to C_1 and C_2 of the megger and the two inner terminals are connected to P_1 and P_2 of the megger. The earth resistivity P in ohm-cm is given by

$$P = 2 \wedge aR$$

Where R is the steady reading on the megger.

Equipment and Materials

<i>S.No</i>	<i>Item</i>	<i>Range and Rating</i>	<i>Nos.</i>
(i)	Earth tester or megger	500 V	1
(ii)	electrodes	G.I	4
(iii)	Connecting wires	3A	
(iv)	Hammer		

Procedure

- (i) Drive four electrodes into the ground at equal distance from each other. The depth of the insertion of the electrode should not be more than one twentieth of the separation.
- (ii) Make the connections as shown in Fig 22.1
- (iii) If a megger is being used, adjust the variable resistances to the

middle of the scales and rotate the crank shaft.

- (iv) Adjust the variable resistances so that the null point is obtained. The value of the resistance at null point is the reading R .
- (v) Repeat steps (i) to (iv) for different values of a .

Tabular Record of Observations

<i>S.No</i>	<i>Distance</i>	<i>R</i>	<i>P = 2 \wedge aR</i>	<i>Remarks</i>
	<i>'a'</i>			
i)				
ii)				
iii)				

Precautions

- (i) Insert the electrodes in such a way that they are in a straight line.
- (ii) The depth of the insertion of the electrodes should be less than one twentieth of the distance 'a'.

Questions

- (i) On what factors does the resistivity of earth depend?
- (ii) What treatment should be given to an earth pit for decreasing earth resistance ?

Inspection of Overhead Lines

Specific Objective

To familiarize the students with the practices adopted in general inspection of overhead lines.

Related Information

After overhead electrical lines are constructed and put into operation, they must be inspected periodically, at least once a year, to check whether the poles, towers, insulators, conductors lightening arresters, switches and fuses are in good conditions. This is absolutely necessary if the system is to be in good operating condition. Due to internal stresses and strains and natural hazards, gradual deterioration of different parts takes place. By a general inspection such deterioration may be detected and corrective actions may be taken. It must be realized that the failure of any part in the line may affect the power supply and, therefore, the general inspection has to be done with all care. The inspection of a line is conducted by a patrolman or a patrol-group.

A good patrolman should concentrate on the task at hand, know just what is expected of him, and be able to make complete reports indicating the condition of different parts.

The principal conditions, a patrolman should observe and report along any line are as follows:

- Insulators : Broken, cracked, badly leaning, swinging or flashed insulators (give the pole number).
- Poles : Poles broken off or leaning out of line 2 ft. or more at the top or requiring filling at the base.
- Conductors : Broken strands, burnt spots, undue or uneven sagging, foreign objects such as kites, kite strings or tails, pieces of wire, tree limbs, etc. hanging on, or near any conductor.
- Ground leads: Broken or loose from the support.

Tie wires : Broken or burnt
 Cross arms : Cross arms split, rotted or loose.
 Insulator pins: Bad or broken pins or pins partly out of cross arms.
 Fuses : Broken glass or loose connections
 Guy wires : Broken or slack wire
 Lightning arrestors: Loose ground conditions, flashed, broken supports.
 After the inspection, the report should immediately be given, preferably in a proforma. A model is given below

Patrolman's Report

Name:
 Line from Pole No. to Pole No.....Date...
 Patrol of the line reveals the following deteriorating conditions and defects:-
 Insulators:
 Conductors:
 Cross arms:
 Pins:
 Lighting arrestors:
 Tiewire/Guywire:
 Ground wire
 and ground leads:

Trees, buildings
 roads under construction menacing line:

Special or miscellaneous equipment:
 Remarks

Signature of Patrolman.....

Date.....

Questions

- (i) Why is inspection of lines important ?
- (ii) What should be the qualities of a good patrolman ?
- (iii) submit a patrolman's report after you have come back from the patrolling.

Note:

The instructor should take the students to the site where a general patrol on the line is going on and acquaint the students with the practices adopted. Each student should submit a separate patrolling report.

ACTIVITY NO. 24

Location of Low Resistance Cables Faults

Specific Objectives

- (i) To acquaint the students with different types of cable faults
- (ii) To locate the position of a low resistance fault in an underground cable by the Murray Loop Test.

Related Information

A fault in a cable may occur due to deterioration of the insulation of the conductor. Then power cannot be despatched through to the cable load. Cable faults can be classified broadly into two categories:

- (a) insulation failures when the insulation between conductors or between the conductor and earth loses its insulating property; and
- (b) conductor failures when any of the conductors is broken.

A diagnosis of the type of fault may be made by testing the insulation resistance with the help of a megger and conducting continuity tests.

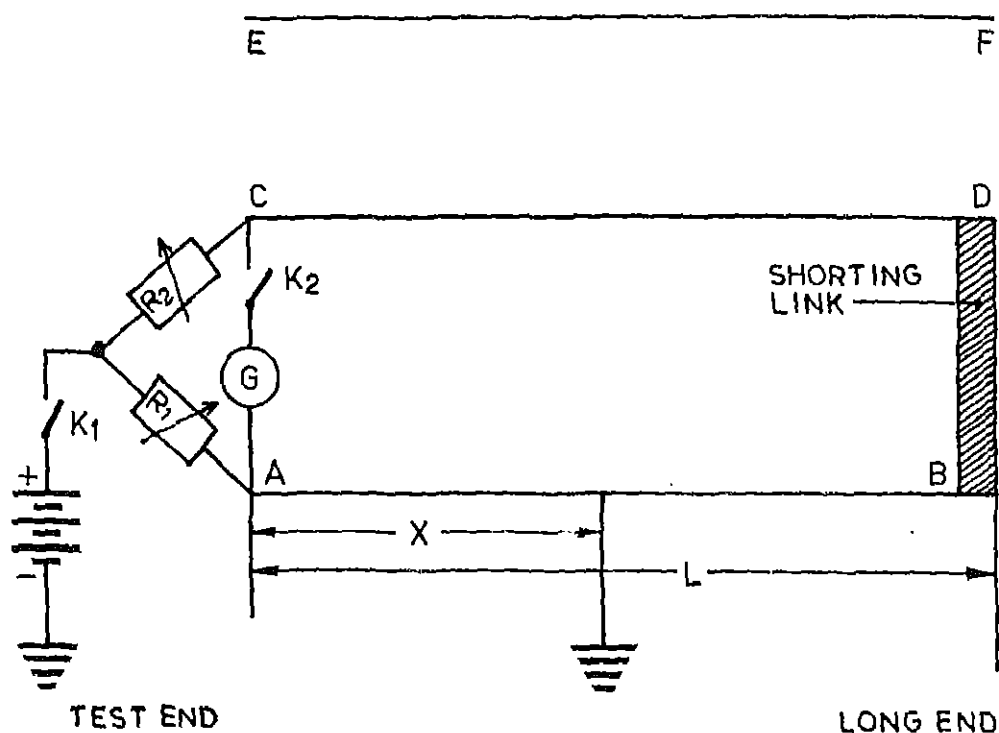
The Murray loop test is a method by

which the exact location of the fault in the under ground cable can be measured when the fault is of (a) above, and when the insulation resistance of a conductor to earth falls to a very low value, so that the conductor may be considered to be shorted to earth.

In Fig. 24.1; the faulty conductor is looped to a sound conductor of the same cross sectional area and a resistance box with two sets of coils is connected across the open ends of the loop. A galvanometer is also joined across the ends of the loop and a battery supplies the test current. If the resistance R_1 and R_2 so adjusted that the galvanometer gives no deflection even when the battery key is closed. X = distance to fault

$$X = 2 \frac{R_1}{R_1 + R_2} \times \text{cable length}$$

After the location of the fault, the earth around this point on the cable route is dug up and repair work can be undertaken.



AB, CD, EF - 3 CONDUCTORS OF A 3-CORE CABLE

Fig. 24.1 Circuit diagram for Murry Loop Test.

Equipment and Materials

Procedure

S.No	Item	Range of Rating	Quantity.
i)	Resistance box	Two sets of coils each having a resistance of 1000 ohms variable in steps of 1, 10 and 100.	1
ii)	D.C. battery	12 V	1
iii)	Galvanometer	1 mA/division	1
iv)	one-way key	-	2
v)	Connecting wires	-	-

- (i) Connect the resistance box and galvanometer across the open ends of the loop formed by conductor AB and conductor CD or DE. The galvanometer should be connected through key K_2 .
- (ii) The battery is connected between the earth and the common point of the resistance box through key K_1 .

- (iii) Short circuit the conductors AB and CD or DE (as chosen in step (i) above at the load end.
- (iv) Close key K_1 and by closing key K_2 momentarily, observe the deflection of the galvanometer.
- (v) By repeatedly opening and closing key k and changing the resistances R_1 and R_2 the galvanometer's deflection is brought to null.
- (vi) Determine the cable length from the route diagram or system manual.
- (vii) Calculate the length of the fault point from the test point by using equation given.

- (ii) The short circuit of the conductor should be properly made.
- (iii) Keys K_1 and K_2 should not be kept closed for long.

Questions

- (i) What are the broad types of cable faults ?
- (ii) Why is it necessary to locate the fault ?
- (iii) How do you know that the fault is due to insulation failure?

Tabular Record of Observations:

Length of cable =

<i>S.No</i>	<i>R₁ in ohms</i>	<i>R₂ in ohms</i>	<i>Galvano- meter deflection</i>
-------------	----------------------------------	----------------------------------	--

$$X = 2 \frac{R_1}{R_1 + R_2} \times \text{cable length}$$

Precautions

- (i) The battery should be fully charged.

ACTIVITY NO. 25

Preparation of Trenches-Cable Ducts

Specific Objectives

The students should be able to:

- (i) mark the route of the cable on the ground;
- (ii) dig the trench along the route as per dimensions; and
- (iii) prepare the trench for laying the cable.

Related Information

Cables are laid underground to prevent electrical accidents and to minimize electrical breakdowns due to damage caused to the cables.

Cables are laid in trenches and buried. Before the trenches are dug, the shortest trench route is selected. During this process, due care is to be taken to avoid obstacles like underground water mains, sewer mains, telephone cables, earlier laid power cables, culverts, drains, etc. A cable trench is illustrated in Fig 25.1.

Trenches are dug 90 to 120 cms. deep and 250 cms wide. However, the width of the trench may vary depending upon

the number of cables to be laid together. Round pits are dug at both ends of the trench and in the centre to accommodate the loops. Sand is put at the bottom to prevent moisture, and soil corrosion. Bricks are laid on either side for providing mechanical protection and preventing the falling of excavated earth on the sand and later on the cable.

Equipment and Materials

- (i) Measuring tape
- (ii) Pickaxe
- (iii) Spade
- (iv) Trowel
- (v) Sand
- (vi) Bricks
- (vii) Heavy gauge G.I. pipe

Procedure

- (i) Mark the route for the cable with the help of the pickaxe.
- (ii) Dig the trench on the marked route about 90 to 120 cms. deep and 50 cms. wide.

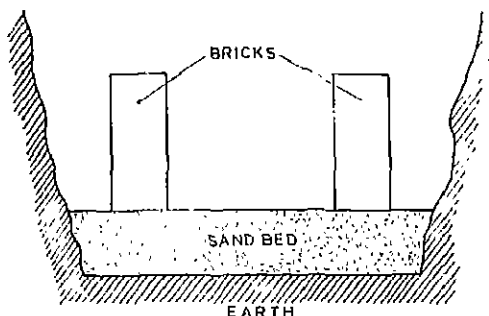


Fig. 25.1 Cable Trench

- (iii) If more than one cable is required to be laid together, then the width could be increased by the addition of 40 cms. per additional cable.
- (iv) Spread 5 to 10 cms layer of sand at the bottom throughout the length of the trench.

- (v) Place the side bricks.

Precautions

- (i) The dimensions of the trench should be strictly followed.
- (ii) Never deviate from the decided route.
- (iii) Provide G.I. pipe at obstacles.
- (iv) Avoid sharp bends.

Questions

- (i) What arrangements are made at obstacles?
- (ii) Why are bricks provided on either side throughout the trench?
- (iii) Why is sand laid at the bottom of the trench ?

Laying Underground Cables

Specific Objectives

The students should be able to:

- (i) handle and mount the cable drum for unreeling cables safely; and
- (ii) lay the cables in the trench and bury them.

Related Information

Cables are laid underground for connecting:

- (i) Generators to transformers in outdoors yards in power stations;
- (ii) sub-station bus bars to transformers/overhead lines;
- (iii) bulk consumers' receiving equipment with overhead lines.

In large cities where it is not possible to construct overhead lines, underground cables are used. Underground cables prevent electrical accidents and minimize interruptions of the supply. Laying of cables is illustrated in Figs. 26.1 and 26.2.

In the trenches, normally one cable is laid but where it is required to lay more cables, it is necessary to maintain a dis-

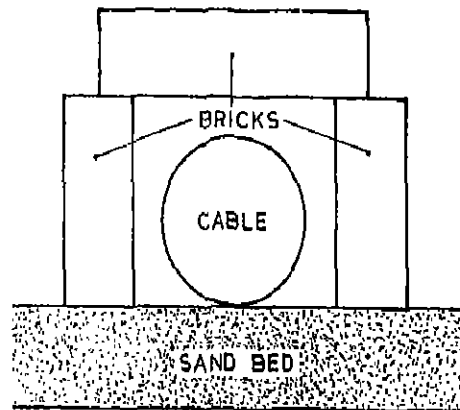


Fig. 26.1 Direct laying of cables

tance of atleast 40 kms in both horizontal and vertical directions in order to avoid mutual heating and to ensure that a fault in one cable does not affect the other in the same trench.

Normally, cables are laid in straight lines but loops are also formed at both ends and in the centre so that in the event of faults the length of the cable could be gained from the nearest loop, thereby avoiding jointing.

Sand is put all around the cable to protect it from moisture and corrosion. Bricks are used to prevent mechanical damage to the cable.

At places where it is not possible to avoid obstacles like power telephone cables, water-mains, sewer line, drains, railway lines, roads, culverts, etc. and the cables are required to cross them, the cables should be passed through heavy gauge G.I. pipes.

bricks placed in the round pit/trench by pulling it from the bottom side of the drum.

- (v) Fill in the space over and around the cable with sand.
- (vi) Place the bricks on the top of the side bricks.
- (vii) Cover the trench by back filling the earth.
- (viii) Insert the cable route indicators at suitable distances.

Equipment and Materials

- (i) Mechanical jacks or wooden fixtures for mounting the cable drums in accordance with the size of the cable drum.
- (ii) Spindle (crowbar /G.I. pipe)
- (iii) Wooden blocks for braking
- (iv) Measuring tape
- (v) Spade
- (vi) Tasla
- (vii) Bricks
- (viii) Sand
- (ix) Cable route indicators.

Procedure

- (i) Dig and prepare the cable trench as per activity in 25.
- (ii) Bring the cable drum to the site i.e. the starting end of the trench.
- (iii) Mount the cable drum on the jacks/wooden fixtures keeping in view the direction marked on the drum "ROLL THIS WAY"
- (iv) Lay the cable in the pit and trench, between the two side

Precautions

- (i) While laying a cable, see that no kinks are formed in the cable.
- (ii) While mounting the cable drum, the direction marked on the drum must be taken care.
- (iii) The cable should be drawn from the bottom of the drum in such a way that it does not get dragged on the earth and the armouring jute serving is not damaged.
- (iv) It is necessary to avoid sharp ends while laying the cables.
- (v) Put heavy gauge G.I. pipe beneath/above any obstacle and pass the cable through the pipe.

Questions

- (i) Why are cables laid underground?
- (ii) What should be the minimum depth and width of the cable trench?
- (iii) Why are loops formed at both ends and in the centre of the

cable?

- (iv) If more than one cable is laid in the same trench, what is the minimum distance that has to be maintained between them?
- (v) What is the purpose of putting sand all around the cables in the trenches?
- (vi) How are cables are protected from mechanical damage in the trenches?
- (vii) Why is it necessary to pass cables through G.I. pipes while crossing any obstacle?



Fig. 26.2 Cable laid in Cable Trench

ACTIVITY NO. 27

Cutting and Sealing Cable Ends

Specific Objectives

The students should be able to:

- (i) cut the cable; and
- (ii) seal the cable ends.

Related Information

After drawing out the required length of paper insulated lead covered double steel taped armoured cable (PILDSTA), it is to be cut, and if the left-over cable length in the drum is not to be used in the immediate future, its cut ends are to be properly sealed, failing which the cable will absorb moisture. This will deteriorate the paper insulation and make the cable unfit for use.

Equipment and Materials

- (i) Hacksaw with blade
- (ii) Insulated combination pliers 20 cms.
- (iii) Screw driver 20 cms.
- (iv) Sharp edged knife 20 cms.
- (v) Blow lamp

- (vi) Plumbing metal rod (soldering rod 60:40)
- (vii) Soldering flux
- (viii) Tallow cloth
- (ix) Steel binding wire 14 SWG
- (x) Emery paper No. '0'
- (xi) Kerosene oil
- (xii) Stove pin
- (xiii) Match box
- (xiv) Cotton waste

Procedure

(A) *For PILDSTA Cable*

- (i) Make a cut mark with the hack-saw on the cable, where it is to be cut.
- (ii) Bind the cable with binding wire, 2 cms. from each side from the cut mark.
- (iii) Cut the cable with the hack-saw as illustrated in Fig. 27.1.
- (iv) Re-bind with the binding wire at distance of 15 cms. backwards.
- (v) Cut and peel out the jute serving with the sharp-edged knife.

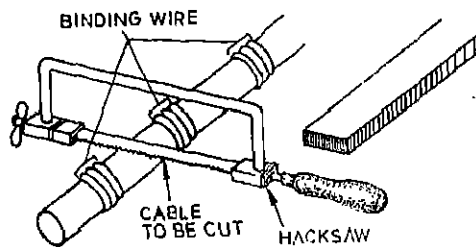


Fig. 27.1 Cutting the cable for end sealing

- (vi) Cut the armouring in front of the binding wire by filing all around with the triangular file and remove by nicking.
- (vii) Heat with the blow lamp and peel off the impregnated and adhesive paper insulation.
- (viii) Clean the lead sheath with kerosene oil.
- (ix) Scrape clean the lead sheath nearer to the end with emery paper.
- (x) Apply flux on the open ends of the conductors and lead sheath.
- (xi) Heat it up with the blow lamp, apply the solder rod till the end is completely covered with molten solder illustrated in Fig. 27.2.
- (xii) Keep on gradually but intermittently heating the solder deposit and rub it with tallow cloth till it takes a round shape and bending takes place between the solder and lead sheath.
- (xiii) Allow it to cool.

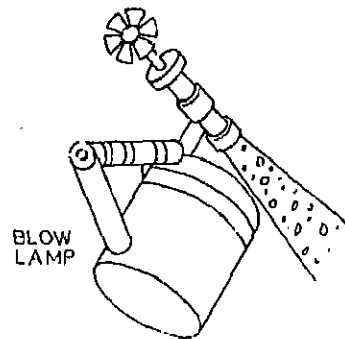
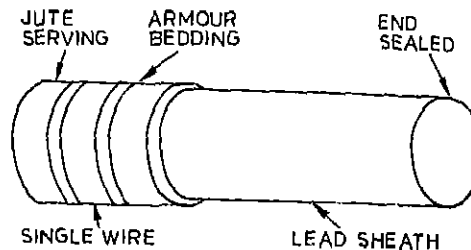


Fig. 27.2 Cable and sealing

(B) For P.V.C. Tropodure cables

- (i) Make a cut mark with the hacksaw on the cable where it is to be cut.
- (ii) Seal the cable end by wrapping the H.T. tape all around.

Precautions

- (i) The cable should be binded before cutting.
- (ii) The cable armour should be cut with hacksaw.
- (iii) Ensure that the lead sheath does not start melting while heating with the blow lamp.

- (iv) Ensure that there is no pinhole left and no cracks have developed on the solder at the seat end.

Questions

- (i) Why is it necessary to seal the

cable ends?

- (ii) What precautions are to be observed while sealing the cable?
- (iii) What is the function of soldering flux in this practical?

Preparation of Cable Ends for Jointing

Specific Objective

To develop skills in preparing cable ends for termination and jointing.

Related Information

Before jointing or termination, the conductors of the cable are to be exposed after removing the armouring and different layers of insulation etc. In paper insulated lead covered double steel tapped armoured cable (PILDSTA), the individual conductors are covered by impregnated paper insulated tape. All the cores in a cable are warmed and again wrapped by impregnated paper tape. Lead sheathing is provided over this formation for preventing ingress of moisture in the cable. Armours in the form of steel tapes or zinc steel wires are wrapped over this lead sheathing to provide mechanical protection. Jute serving treated with insulating compound is also provided over the armouring for the prevention of soil corrosion.

Nowadays poly-vinyl-chloride insu-

lated cables (P.V.C. Tropodure cables) are also extensively used. In these cables, the individual conductors are provided with P.V.C. insulation and all the cores are again covered with P.V.C. tough sheathing. In some cases, the armouring is also provided underneath the P.V.C. sheathing. The steps for preparation of cable and are illustrated in Fig. 28.1.

Equipment and Materials

- (i) Sharp-edged knife 20 cms.
- (ii) Insulated combination pliers 20 cms.
- (iii) Ball-Pein hammer 500 gms.
- (iv) Screw driver 25 cms.
- (v) Blow lamp.
- (vi) PILDSTA cable length 3 metres.
- (vii) P.V.C. Tropodure cable length 3 metres.
- (viii) L.T. Termination box of suitable size
- (ix) Steel binding wire 14 SWG
- (x) Triangular file 20 cms.
- (xi) White cotton tape

- (xii) Empire adhesive tape.
- (xiii) High-tension insulating tape.
- (xiv) Kerosene oil
- (xv) Stove pin
- (xvi) Match-box
- (xvii) Cotton waste.

Procedure

(A) For PILDSTA Cables

- (i) Mark the cable length to be stripped off, from the end according to the size of the termination box plus 30 cms. margin, or as required.
- (ii) Bind the cable over the mark, above the jute serving, by binding wire.
- (iii) Cut and peel out the jute serving with the sharp-edged knife.
- (iv) Place wire binding, approximately 10 turns, over the steel armouring, near the mark.
- (v) Cut armouring in front of the binding wire by filing all around with the triangular file and remove by nicking.
- (vi) Heat with the blow lamp and peel off the impregnated and adhesive paper insulation.
- (vii) Clean the lead sheathing with kerosene oil.
- (viii) Scrape bare the lead sheath for 2 to 3 cms. ahead of the wire binding.
- (ix) Wrap the adhesive insulation tape near the edge of the cut lead sheathing.

- (x) Cut off the filler with a knife from inside to outside.

- (xi) Unworm the cores, straighten them and bind with impregnated twine near the termination points.
- (xii) Remove the paper insulation at the end of the conductors with a knife, to the length required.
- (xiii) Wrap the white cotton tape/empire tape over the paper insulation, around the individual cores of the cable.

(B) For P.V.C. Tropodure Cables

- (i) Mark the cable length to be stripped off from the end according to the size of the termination box plus 30 cms. margin, or as required.
- (ii) Cut the outer P.V.C. tough sheath with the sharp-edged knife.
- (iii) Bind the armour with steel binding wire 3 cms. ahead of this cut mark.
- (iv) Cut the armouring in front of the binding wire by filing the steel strands with the triangular file and remove.
- (v) Twist back all the armours over the P.V.C. tough sheath.
- (vi) Remove the P.V.C. membrane.
- (vii) Un-worm the cores of the cable and straighten them.
- (viii) Remove the P.V.C. insulation at the ends of the conductors with a knife to the length required.

Precautions

- (i) Never use a hacksaw for removing lead sheathing or armouring.
- (ii) Keep sufficient extra margin while marking the cable for stripping off.
- (iii) While cutting layers of armours/lead sheath/insulation due care should be taken so that the next layer does not get damaged.

Questions

- (i) What precautions are observed while preparing cable ends?
- (ii) Why is a hacksaw not allowed to be used?
- (iii) Why is it necessary to bind the cable or cores before cutting any layer of armouring or insulation?

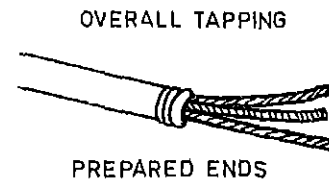
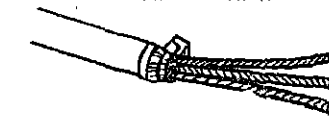
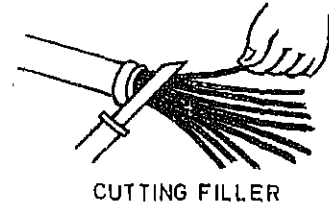
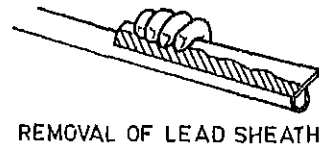
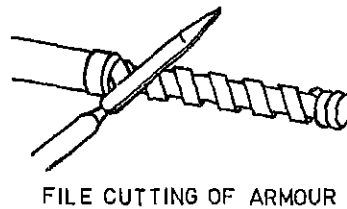
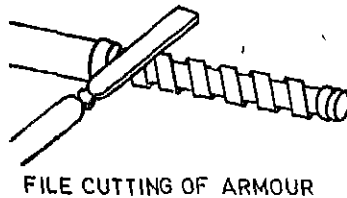
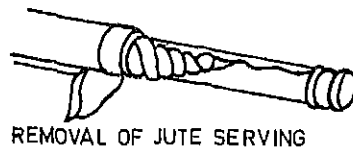


Fig. 28.1 Steps in Preparation of Cable ends

Ferrule Preparation

Specific Objective

- (i) To measure overall diameter of the core conductor.
- (ii) To prepare the template according to the diameter of the conductor.
- (iii) To prepare the ferrule over the template.

Related Information

A ferrule is a slotted metal tube made of copper or aluminium sheets. This is used in straight through joints for connecting the respective conductors of two underground cables rigidly. A slit is provided for the penetration of molten solder uniformly all around the conductor inside the ferrule. This can also be prepared out of copper or aluminium tubes of suitable thickness and diameter, if available, by cutting a 2 mm. wide slot. Tinning on the inside surface of copper ferrule is essential before soldering for lesser contact resistance and proper sweating. To prepare a ferrule of the required dimensions,

it is essential to prepare a template which acts as a fixture. This should be prepared on a lathe machine out of MS. Nowadays, solderless crimping type ferrules are also available which, instead of soldering, can be crimped by a crimping tool.

Equipment and Materials

- (i) Outside micrometer
- (ii) Hacksaw with blade
- (iii) Measuring scale
- (iv) Straight edge snip 25 cms.
- (v) Ball-pin hammer 1/2 Kg.
- (vi) Copper or aluminium sheet 20 cms x 20 cms. (thickness of the sheet to be decided by the size of the cable).
- (vii) Blow lamp
- (viii) Ladle tool
- (ix) Solder melting pot
- (x) Tongs 30 cms.
- (xi) Cable length (copper/aluminium)
- (xii) Copper/aluminium tube of suitable size
- (xiii) Kerosene oil

- (xiv) Stove pin
- (xv) Match-box
- (xvi) Emery paper
- (xvii) Solder (60 : 40/ALCAP)
- (xviii) Soldering flux (copper/aluminium)
- (xix) Bricks-8
- (xx) Cotton waste

Procedure

- (i) Measure the diameter of the core conductor with help of the outside micrometer.
- (ii) Prepare a template on the lathe out of M.S. rod as per dimensions to be decided by the overall diameter of the core conductor.
- (iii) Calculate the circumference of the ferrule to be prepared by the formulas πd , d is the diameter of the core conductor.
- (iv) Subtract 2 mm. out of the calculated circumference to decide the length of sheet required for preparing the ferrule.
- (v) Cut the sheet 10 cms. wide to the length.
- (vi) Place the cut sheet over the template and bring it to a tubular shape by tapping gently with a hammer.
- (vii) Clean the ferrule, particularly the inner-core, with emery paper.
- (viii) In case the copper/aluminium tube of the required size and thickness is available, the ferrule

can be prepared by:

- (a) cutting 10 cms length out of the tube; and
- (b) cutting 2 mm wide slot with the help of the hacksaw.

For copper ferrules only for tinning

- (i) Melt the solder (60:40) in the solder melting pot.
- (ii) Apply flux, particularly inside the ferrule.
- (iii) Pour the molten solder by a ladle on and in the ferrule by holding it above the melting pot with a tong.
- (iv) Keep on pouring the solder till it gets fully tinned.
- (v) Allow it to cool.

Precautions

- (i) Measure the diameter of the core conductor carefully.
- (ii) Subtract 2 mm out of the calculated circumference of the conductor.
- (iii) Clean the inner surface of the ferrule with emery paper.
- (iv) The template must be prepared to the exact dimensions.
- (v) Tap gently while shaping the Ferrule.
- (vi) Tinning is not required to be done on or in aluminium ferrules.

Questions

- (i) What do you understand by a ferrule?

- (ii) Why are ferrules used?
- (iii) Why is it necessary to tin the inner surface of a copper ferrule?
- (iv) Why is a slot essentially provided on the ferrule?

Note:

Solderless crimping type ferrules are also available these days which are just crimped with the core conductors of the cable ends on both sides with the help of a suitable crimping tool.

ACTIVITY NO. 30

Soldering/Crimping of Lugs with Cable Ends

Specific Objectives

The students should be able to:

- (i) select suitable; for the given size of conductor.
- (ii) skin the conductor to the required length.
- (iii) solder/crimp the lug with the conductor end properly.

Related Information

To ensure proper and tight connections of cables with the terminals of electrical equipment like bus-bars, transformers, switch gear, large capacity motors, etc. the ends of cables are fitted with suitable lugs. For rigidly fitting the lugs with the cable ends, they are either soldered or

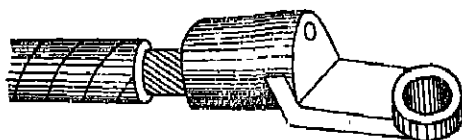


Fig. 30.1 Lug soldered cable end

crimped with the conductors. This soldering/crimping of the lugs reduces contact resistances at the terminals where they are fitted, which in turn reduces heat generation at the point of contact. Lug soldered cable end is shown Fig 30.1.

Equipment and Materials

- (i) Blow lamp
- (ii) Ladle pan
- (iii) Ladle tool
- (iv) Tong/gas pliers
- (v) Knife
- (vi) Hacksaw
- (vii) Ball pein hammer 1/2 kg.
- (viii) Crimping dies
- (ix) Cable length
- (x) Crimping tools
- (xi) Copper/aluminium lugs/solderless crimping lugs
- (xii) Emery paper 'O'
- (xiii) Solder 60:40/ALCA
- (xiv) Cotton waste
- (xv) Soldering flux/Eyre flux
- (xvi) Stove pin

- (xvii) Kerosene oil
- (xviii) Match-box.

cool.

Procedure

(A) Soldering Lug with the Cable end

- (i) Select the suitable copper/aluminium lug keeping in view the current capacity, size and shape of the cable conductors.
- (ii) Clean the copper lugs with emery paper both inside and outside the socket.
- (iii) Put the cut mark on the cable in accordance with the depth of the lug socket.
- (iv) Skin the conductor and clean it with emery paper to give a skinning surface.
- (v) Melt solder (60:40 or ALCAP) as per requirement.
- (vi) Apply flux to the conductor end and lug surface and lug socket interior.
- (vii) First heat up the conductor a bit, then tin it by pouring molten solder. Alternately the cable end may be dipped in the molten metal for some time and removed.
- (viii) Heat the lug by repeatedly pouring the molten solder.
- (ix) Fill in the lug socket by molten solder.
- (x) Insert the tinned conductor's end in the socket of the lug containing molten solder.
- (xi) Allow the above assembly to

(B) Crimping Lug at the Cable end.

- (i) Select the required size solderless crimping type lug.
- (ii) Clean the lugs outer surface and the inner surface of the lug socket with a cloth.
- (iii) Skin the conductor at the end of the cable and clean it with emery paper.
- (iv) Select the crimping die and tool according to the size of the lug.
- (v) Push the lug on the conductor end and keep screwing it till it gets completely fitted.
- (vi) Place the lug between the die.
- (vii) Operate the tool for crimping.

Precautions

- (i) The lugs selected should be of the same metal as the conductor cable.
- (ii) The lugs selected should be of the required size, shape and rated capacity.
- (iii) Aluminium lugs and solderless crimping type lugs do not need to be tinned.
- (iv) Use appropriate solder and soldering flux, depending upon the metal of the conductor.
- (v) Conductor must be tinned properly before they are soldered.
- (vi) After soldering, the lugs should be held in the same stationary position till they get completely

cooled.

- (vii) In solderless crimping, the die should be selected exactly according to the size of the lug.

Questions

- (i) Why it is required to solder a lug/crimp a lug to the cable and?
(ii) What would happen if the lug selected is not of the proper size,

shape and rated current capacity?

- (iii) Why is it necessary to tin the conductor before soldering with the lug?
(iv) What will happen if the lug is shaken before the soldered assembly of the lug and cable is completely cooled?

ACTIVITY NO. 31

Making Straight Through Joints in Underground Cables

Specific Objective

The students should be able to make a joint between two cable lengths using a straight through joint box.

trical insulating protection and to avoid mechanical stresses on the joints they are housed in specially made cable joint boxes and sealed with insulating bitumen compound. A straight through joint of cable is shown in Fig. 31.1.

Related Information

When it is required to extend the length of a cable, another cable of the same size, of the required length can be jointed with it.

As the armours and insulation over the conductors have to be removed to some extent while jointing the conductors of the cable, the mechanical and electrical protection provided by them gets impaired. This makes the cable vulnerable to damage. In order to compensate and re-provide the mechanical and elec-

Equipment and Materials

- (i) Two lengths of PILDSTA armoured cables/PVC Tropodure armoured cables.
- (ii) Straight through joint box complete with nuts and bolts/complete kit of M-seal straight through joint box.
- (iii) Brass sleeves of cable size.
- (iv) Ferrules of suitable size of copper/aluminium.
- (v) Crimping tool

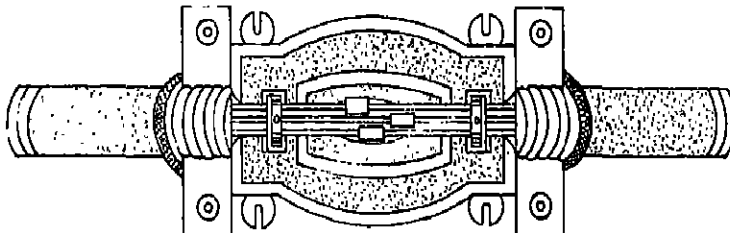


Fig. 31.1 A Finished Straight through Joint section

- | | | |
|-----------|--|---|
| (vi) | Crimping dies | cms x 20 cms x 15 cms -2 |
| (vii) | Blow lamp | (xxxix) Copper/alluminium sheet of 1 |
| (viii) | Melting pot for solder | mm thickness or as required. |
| (ix) | Ladle tool | (xl) Template as per core conduc- |
| (x) | Pot for melting bitumen compound | tor size of cable |
| (xi) | Tong 20 cms. | (xli) Insulation tester |
| (xii) | Gas pliers 20 cms. | (xlii) Insulated combination pliers |
| (xiii) | D.E. spanner set. | 20 cms |
| (xiv) | Sharpedged knife 20 cms. | |
| (xv) | Screw driver 20 cms | Procedure |
| (xvi) | Shear | (A) <i>For PILDSTA Cables</i> |
| (xvii) | Flat file 25 cms. | (i) Prepare the ends of both cable |
| (xviii) | Triangular file 20 cms. | lengths according to the size of |
| (xix) | Ball-pen hammer 1/2 kg and 1kg. | the straight through joint box as |
| (xx) | Hacksaw with blade | explained in activity no 28 on the |
| (xxi) | G.I. bucket | Preparation of cable ends for |
| (xxii) | Tallow | jointing. |
| (xxiii) | Tallow cloth | (ii) Prepare the ferrules out of cop- |
| (xxiv) | Marking cloth 2 metres. | per/aluminium sheet depending |
| (xxv) | Empire tape | upon the metal of the core conduc- |
| (xxvi) | White cotton tape. | tors of the cable as explained |
| (xxvii) | High tension impregnated tape | in activity no. 29 on Ferrule Pre- |
| (xxviii) | Kerosene oil | paration. |
| (xxix) | Stove pin | (iii) Dismantle the straight through |
| (xxx) | Firewood | joint box and clean it thoroughly. |
| (xxxi) | Match box | (iv) Pass the cables through the brass |
| (xxxii) | Bricks 8 | sleeves in such a way that half of |
| (xxxiii) | Bitumen compound | the exposed lead sheath remains |
| (xxxiv) | Steel binding wire 14 SWG | outside the sleeve. |
| (xxxv) | Bare copper wire 6 SWG | (v) Position the sleeves in the lower |
| (xxxvi) | Emery paper No. 'O' | half of the joint box. |
| (xxxvii) | Hylam sheet of size 20 cms x 5 cms x 5 mm 2 to 3 | (vi) Support the cables at both ends |
| (xxxviii) | Wooden blocks of size 30 | on wooden blocks |
| | | (vii) Tin the ferrules and exposed the |
| | | core conductors ends of both the |
| | | cables. |
| | | (viii) Insert the ferrules on the respec- |

- tive core conductors of both the cables and solder them.
- (ix) Tape the core conductors including soldered ferrules first with empire tape, then with high tension tape and lastly with white cotton tape.
- (x) Place the taped jointed core conductors neatly in the lower half of the joint box.
- (xi) Insert the hylam spacers between the core conductors
- (xii) Assemble the upper half of the joint box and tighten with nuts and bolts.
- (xiii) Bind the steel binding wire, 2 to 3 turns, near the exposed lead sheath on both the sides. (Re-tighten if bound earlier during the ends preparation).
- (xiv) Clean the exposed portions of the lead sheath and brass sleeves first with kerosene oil and then with emery paper.
- (xv) Apply the flux on the exposed lead sheath and sleeve and gently heat with the blow lamp.
- (xvi) Deposit solder by gently melting the solder rods all around the lead sheath and sleeve junction.
- (xvii) Gently but intermittently heat the solder deposit and bring it to the semi spherical shape by rubbing with tallow and tallow cloth.
- (xviii) Ensure that the solder is properly mated over the lead sheath and brass sleeve junction.
- (xix) Repeat steps (xv) to (xviii) at the other end of the joint box.
- (xx) Bond metal sheaths of both cables along with the joint box by two bare copper wires of 6 SWG by means of clamps at both ends.
- (xxi) Melt the Bitumen compound in the melting pot with the help of firewood.
- (xxii) Remove both the vent plugs from the top of the joint box.
- (xxiii) Gently pre-heat the joint box with the blow lamp.
- (xxiv) Pour the molten compound through one of the vent holes and fill in the joint box completely but slowly.
- (xxv) Leave the joint box for cooling.
- (xxvi) Insert the joint box and top up again with molten compound if necessary and let it cool.
- (xxvii) Fix back both the vent plugs in the ventholes.
- (xxviii) After the joint box has attained the atmospheric temperature, test the cable for continuity and insulation resistance as explained in activity no. 33 on "Testing underground cables."
- (xxix) Remove the wooden supports. The joint is now ready to be buried in the pit
- (B) For P.V.C. Tropodure Armoured Cables
- (i) Prepare the ends of tropodure

- cable lengths according to the size of the M-seal straight through joint-box as explained in activity no: 28 on "Preparation of cable ends for jointing".
- (ii) Prepare the ferrules of copper/aluminium sheet depending upon the metal of the core/conductors of the cables as explained in activity No. 29 on "Ferrule Preparation".
 - (iii) Open the M-seal joint box kit and take out the top and bottom halves of the joint box.
 - (iv) Support the cable at both ends on wooden blocks.
 - (v) Insert the cable in the lower half of the joint box in such a way that half of the exposed armouring (about 3 cms) remains outside at both ends of the joint box.
 - (vi) Insert ferrules on the respective core conductors ends of both the cables and solder joint them.
 - (vii) Tape the core conductors including the soldered ferrule first with empire tape then with high tension tape and lastly with white cotton tape.
 - (viii) Place the taped jointed core conductors neatly in the lower half of the joint box
 - (ix) Insert the hylam spacers between the core conductors.
 - (x) Assemble the upper half of the joint box and tighten with the lower half by binding with steel binding wire at both ends.
 - (xi) Inoculate the vent holes with the sharp-edges.
 - (xii) Cut the tin containing the adhesive liquid, with a knife.
 - (xiii) Break open the seal of the container containing hardener and immediately mix with the adhesive liquid.
 - (xiv) Stir vigorously with a wooden stick/batten.
 - (xv) Pour this mixed compound in the joint box through the inoculated holes gently and top up again if necessary.
 - (xvi) Put back the cut lids on the inoculated holes and fix then with the help of the Araldite-based compound.
 - (xvii) Allow the joint box to cool and the compound to harden
 - (xviii) Connect the armours at both the ends with bare copper wire at two places.
 - (xix) After the joint box has reached atmospheric temperature and the compound has hardened, test the cable for continuity and insulation resistance as explained in activity no. 33 on "Testing of under ground cables".
 - (xx) Remove the wooden supports. The joint is now ready to be buried in the pit.

Tabular Records of Observations**(A) Continuity Test**

<i>R-Y</i>	<i>Y-B</i>	<i>B-R</i>	<i>R-N</i>
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(B) Insulation Resistance between Conductors

<i>R-Y</i>	<i>Y-B</i>	<i>B-R</i>	<i>R-N</i>	<i>Y-N</i>	<i>B-N</i>
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(C) Insulation Resistance between Conductor and Earth

<i>R-E</i>	<i>Y-E</i>	<i>B-E</i>	<i>N-E</i>
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Precautions

- (i) While sealing with Bitumen compound, see that no foreign matter like water, dust, etc. gets into the joint box.
- (ii) Hylam spacers must be provided between the ferrules.
- (iii) While plumbing the end, see that the cable lead sheath does not get

melted.

- (iv) Ensure that no pin holes or cracks appear in the plumbed portions.
- (v) Ensure, by repeatedly topping up the compound, that no air bubbles are trapped inside the joint box.
- (vi) Stir the compound vigorously after mixing the hardener in the case of the M-seal joint.
- (vii) Earth continuity (bonding) must be maintained by connecting the armouring/lead sheath at both the ends with bare copper wire at two places.
- (viii) Never bring the blow lamp near the M-seal joint box.

Questions

- (i) What precautions are to be observed while filling in the Bitumen compound/M-seal compound in the joint box?
- (ii) How is earth continuity (bonding) maintained between the two lengths of cables joined together?
- (iii) Why is it essential to place hylam spacers between the core conductors inside the joint box?
- (iv) Why is it necessary to pre-heat the metal joint box before filling in the Bitumen compound?
- (v) Why is it necessary to test the cable after completion of the joint?
- (vi) What precautions are to be observed while plumbing?

Notes:

The jointing method described here applies to low tension cables and high

tension cables upto 11 KV. For higher voltage cables, the jointing practice becomes a specialized job.

ACTIVITY NO. 32

Making 'T' Joints in Underground Cables

Specific Objective

The students should be able to make a 'T' joint with three cable lengths using a 'T'-joint box.

Related Information

Whenever it is required to tap the main cable for feeding to any branch circuit, 'T' joints are made.

making 'T' joint, the mechanical and electrical protection provided by them gets impaired. This makes the cable liable to damage. In order to strengthen the joint and to re-provide the mechanical and electrical insulating protection and to avoid mechanical stresses on the joint, it is housed in a specially made 'T' cable joint box. 'T' joint of cables is shown in Fig. 32.1.

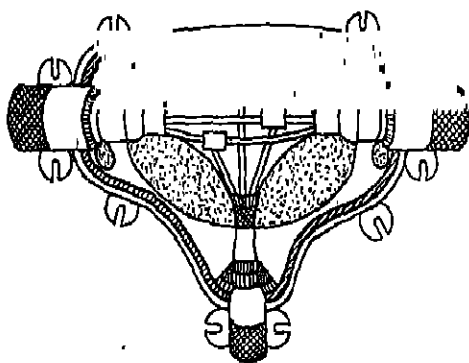


Fig. 32.1 A Finished T-Joint box section

As the armours and insulation of conductors are removed to some extent while

Equipment and Materials

- (i) Three lengths of PILDSTA armoured cables/PVC insulated armoured Tropodure cables.
- (ii) 'T'-joint box with suitable nuts and bolts.
- (iii) Brass sleeves of cable size-3.
- (iv) Lugs of suitable size-12.
- (v) Brass nuts, bolts, spring washers and plain washers for lugs-3 sets.
- (vi) Copper/aluminium sheet of 1 mm thickness.

- | | | |
|----------|--|--|
| (vii) | Complete kit of M-seal 'T' joint box. | 20 cms. |
| (viii) | Hylam sheet 15 cm x 5 cm x 5 mm—two lengths | (xxxvii) Shears |
| (ix) | Insulating Bitumen compound | (xxxviii) Flat file 25 cms. |
| (x) | Solder rods (60:40/ALCAP) | (xxxix) Triangular file 20 cms. |
| (xi) | Steel binding wire 14 SWG. | (xl) G.I. bucket |
| (xii) | Tallow | (xli) Ball pein hammer 1/2 Kg and 1 Kg |
| (xiii) | Tallow cloth | (xlii) Hacksaw with blade |
| (xiv) | Marking cloth 2 metres | (xliii) Bitumen compound |
| (xv) | Empire taps | (xliv) Bare copper wire 6 SWG |
| (xvi) | High tension impregnated tape | (xliv) Insulation tester. |
| (xvii) | Emery paper No. '0' 2 sheets | |
| (xviii) | Firewood | |
| (xix) | Brick | |
| (xx) | Kerosene oil | |
| (xxi) | Stove fin | |
| (xxii) | Match-box | |
| (xxiii) | Wooden blocks 30 cms x 20 cms x 15 cms - 3 | |
| (xxiv) | Crimping tool | |
| (xxv) | Crimping die | |
| (xxvi) | Template of the core-conductor size of the cable | |
| (xxvii) | Blow lamp | |
| (xxviii) | Melting pot for solder | |
| (xxix) | Melting pot for melting Bitumen compound | |
| (xxx) | Ladle tool | |
| (xxxi) | Tongs 20 cms | |
| (xxxii) | Gas pliers 20 cms. | |
| (xxxiii) | DE. spanner set | |
| (xxxiv) | Sharp-edged knife | |
| (xxxv) | Screw driver 25 cms. | |
| (xxxvi) | Insulated combination pliers | |

Procedure

- (A) *For PILDSTA Cables*
- (i) Cut the straight going cable with the hacksaw at the point where tapping is to be made.
 - (ii) Prepare the ends of three cable lengths according to the size of the 'T' joint box as explained in activity no. 28 on "Preparation of Cable ends for jointing".
 - (iii) Dismantle 'T'—joint box and clean it thoroughly.
 - (iv) Pass the cables through the brass sleeves in such a way that half of the exposed lead sheath is outside the sleeve.
 - (v) Position the sleeves in the lower half of the 'T'—joint box.
 - (vi) Support the cables at all the three ends on wooden blocks.
 - (vii) Tin the lugs and exposed core conductors of the three cables.
 - (viii) Solder the lugs with the core

- conductor ends.
- (ix) Tighten the lugs of the respective core conductors of all the three cables together with nuts and bolts, using washers.
 - (x) Tape the core conductors including lugs, first with empire tape, then with high tension impregnated tape and lastly with white cotton tape.
 - (xi) Place the taped/shaped jointed core conductors in the lower half of the joint box.
 - (xii) Insert the hylam spacers between the core conductors.
 - (xiii) Assemble the upper half of the joint box and tighten with nuts and bolts.
 - (xiv) Bind the steel binding wire, 2 to 3 turns, near the exposed lead sheath on all three sides (re-tighten if bound earlier during the ends' preparation).
 - (xv) Clean the exposed portions of the lead sheath and brass sleeves first with kerosene oil and then with emery paper.
 - (xvi) Apply the flux on the exposed lead sheath and sleeve and gently heat with the blow lamp.
 - (xvii) Deposit solder by gently melting the solder rods all around the lead sheath and sleeve junction.
 - (xviii) Gently and intermittently heat the solder deposit and bring it to the semi-spherical shape by rubbing with tallow and tallow cloth.
 - (xix) Ensure that the solder is properly mated over the lead sheath and brass sleeve junction.
 - (xx) Repeat steps (xvi) to (xix) at the other two ends of the 'T' joint box.
 - (xxi) Bond the metal sheaths of the three cables along with 'T' junction box by interconnecting them with bare copper wire of 6 SWG, by means of clamps.
 - (xxii) Melt the Bitumen compound in the melting pot with the help of firewood.
 - (xxiii) Remove all the three vent plugs from the top of the 'T' joint box.
 - (xxiv) Gently pre-heat the joint box with the blow lamp.
 - (xxv) Pour the molten compound through one of the vent holes and fill in the joint box completely but slowly.
 - (xxvi) Leave the joint box for cooling.
 - (xxvii) Inspect the joint box and top up again with molten compound if necessary and allow it to cool again.
 - (xxviii) Fix back all the three vent plugs in the vent holes.

- (xxix) After a couple of hours, when the joint box has reached atmospheric temperature, test the straight and 'T' sections separately for continuity and insulation resistance as explained in activity No. 33 on "Testing underground cables".
- (xxx) Remove the wooden supports. The joint is now ready to be buried in the pit.
- (B) For P.V.C. insulated tropodure armoured cables*
- (i) Cut the straight going cable with the hacksaw at the point where tapping is to be made.
 - (ii) Prepare the ends of the Tropodure cable length according to the size of the M-Seal 'T'-joint box as explained in activity no. 28 on "Preparation of cable ends for jointing"
 - (iii) Open the M-seal, 'T'-joint box kit and take out the top and bottom of the joint box.
 - (iv) Support the cable at all the three ends on wooden blocks.
 - (v) Insert the cables in the lower half of the joint box in such a way that half of the exposed armouring (about 3 cms) remains outside at the three ends of the joint box.
 - (vi) Solder the lugs on all the core conductors of all the three cables.
 - (vii) Tighten the lugs of the respective core conductors of all the three cables together with nuts and bolts and washers.
 - (viii) Tape the core conductors including the bolted, soldered lugs, first with empire taps, then with high tension impregnated tape and lastly with white cotton tape.
 - (ix) Place the taped 'T'-shaped jointed core conductors in the lower half of the 'T'-joint box.
 - (x) Insert the hylam spacers between the core conductors near the bolted lugs.
 - (xi) Assemble the upper half of the joint box and tighten with the lower half by binding with steel binding wire at the three ends.
 - (xii) Inoculate the vent holes with the sharp-edged knife.
 - (xiii) Cut the tin containing the adhesive liquid with a knife.
 - (xiv) Break open the seal of the container containing hardner and immediately mix with the adhesive liquid.
 - (xv) Stirr vigorously with a wooden stick/batten.
 - (xvi) Pour the mixed compound in the joint box through the inoculated hole gently and

- top up again if necessary.
- (xvii) Place back the cut lids on the inoculated holes.
- (xviii) Allow the joint box to cool and the compound to harden.
- (xix) Interconnect the armours at all the three ends with bare copper wire of 6 SWG minimum, at two places.
- (xx) After the joint box has reached atmospheric temperature and the compound has hardened, test the straight section and 'T'-section of the cables separately for continuity and insulation resistance test as explained in activity no. 33 on "Testing of Underground Cables."
- (xxi) Remove the wooden supports. The 'T' joint is now ready to be buried in the pit.

Tabular Records of Observations

(A) Continuity Test

R-Y	Y-B	B-R	R-N
Straight section			
'T' Section			

(B) Insulation resistance between conductors

R-Y	Y-B	B-R	R-N	Y-N
-----	-----	-----	-----	-----

(C) Insulation resistance between conductors and earth

R-E	Y-E	B-E	N-E
-----	-----	-----	-----

Precautions

- (i) While sealing with Bitumen compound see that no foreign matter like water, dust, etc. gets into the joint box.
- (ii) Hylam spacers must be provided near the bolted lugs.
- (iii) While plumbing the ends, see that the cable lead sheath does not get melted.
- (iv) Ensure that no pin-holes or cracks appear in the plumbed portions.
- (v) Ensure, by repeatedly tapping up the compound, that no air bubbles are trapped inside the joint box.
- (vi) Stir the compound vigorously after mixing the hardener in the case of the M-seal joint.
- (vii) Earth continuity (bonding) must be maintained by interconnecting the armouring/lead sheath and joint box at all the three ends.

(viii) Never bring the blow lamp near the M-seal joint box.

(iv) Why is it not necessary to test for insulation resistance for the two sections separately?

Questions

- (i) In underground cables where are the 'T' joints required to be made?
- (ii) What would happen if the assembly of the M-seal joint box is exposed to the blow lamp's flame?
- (iii) Why is it essential to test for continuity for both the sections of the cable separately?

Notes:

- (i) Solderless crimping type lugs can be crimped, instead of soldering, with the help of crimping tools.
- (ii) The jointing method described here applies to low tension cables and high tension cables upto 11 KV. For higher voltage cables, the jointing practice becomes a specialized job.

ACTIVITY NO. 33

Testing of Underground Cables

Specific Objectives

The students should be able to :

- (i) select and handle the testing equipment;
- (ii) make project connections for testing;

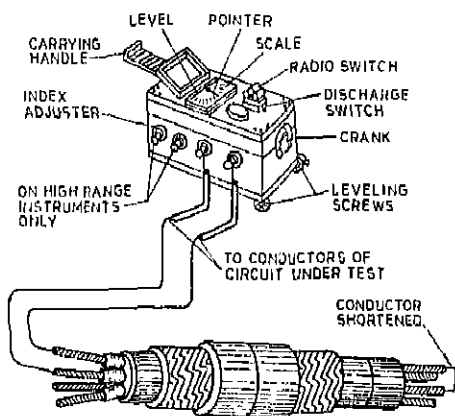


Fig. 33.1 Continuity Test on Under-ground cables

- (iii) test the cable and record the results.

Related Information

To ensure faultless operation of the

cables, the following tests are carried out before they are energized:

- (i) Continuity to ascertain that the core conductors in the cable are continuous throughout the length of the cable. This is illustrated in Fig. 33.1.

- (ii) Insulation resistance:

- (a) between conductors i.e. to measure the resistance offered by insulation between the cores in the cable;
- (b) between conductors and earth i.e. to measure the resistance offered by the insulation between any of the cores in the cable and the metallic sheathing (earth). This is shown in Fig. 33.2. The testing voltages should be as under:

- (i) For low tension (LT) cables-1KV.

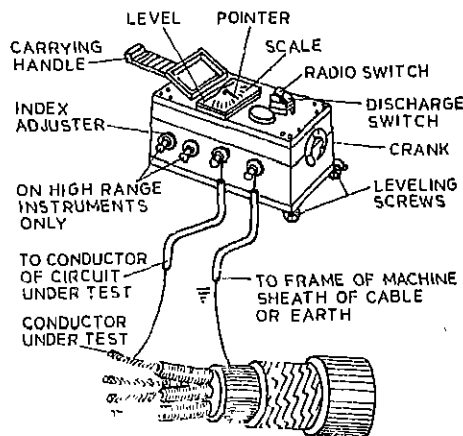


Fig. 33.2 Insulation Resistance Test between Conductors and Earth

- (ii) For high tension (HT) cables-2.5KV
- (iii) For extra high tension (EHT) cables-5.0 KV

A cables, when tested, gets charged due to the capacitive effect and may give shock. Hence, it must be discharged by connecting the core conductors to the metallic sheathing (earth connection)

Equipment and Materials

- (i) Insulation tester
- (ii) Connecting leads
- (iii) Sharp-edged knife.
- (iv) Emery paper.
- (v) P.V.C. insulated cable

Procedure

- (i) Select the insulation tester of the

required voltage capacity.

- (ii) Check the instrument for its performance.
- (iii) Remove the insulation of each core of the cable at both ends with the help of the sharp-edged knife and clean the conductor with emery paper.
- (iv) For the continuity test, short circuit R & Y cores of the cable at one end and check the continuity at the other and by connecting the line and earth terminals of the instrument with the respective open ends of the shorted R & Y cores. On operation, the tester should indicate zero.
- (v) Repeat the test for YB, BR, and in the case of a 4-core cable, any one of the R, Y, B cores and neutral.
- (vi) For measuring the insulation resistance between conductors, first ensure that all the cores at both ends of the cable are separated.
- (vii) Connect the two terminals of the instrument with R & Y cores and operate the tester. It should indicate infinity or, at least, the minimum prescribed value in megohms.
- (viii) Repeat the above test for YB, BR and in the case of a 4-core cable, any of the B, Y, B cores and neutral.
- (ix) For measuring the insulation

resistance between conductors and metal sheathing (earth), connect E terminal of the insulation tester with the earth and L-terminal with the individual cores respectively. Operates the set and record the result.

Tabular Record of Observations

(A) Continuity test

Indication	R-Y	Y-B	B-R	R-N
on dial				

(B) Insulation resistance between conductors

R-Y	Y-B	B-R	R-N	Y-N	B-N

(C) Insulation resistance between conductors and earth

R-E	Y-E	B-E	N-E

Precautions

- (i) The insulation tester should be selected keeping in view the voltage rating of the cable to be tested.
- (ii) The insulation tester must be checked for its performance before it is used.
- (iii) The insulation on the ends of each core of the cable must be removed and the conductors cleaned properly.
- (iv) Each core must be discharged after the test.
- (v) Before testing the cables, be sure that it is isolated from the mains.

Questions

- (i) Why is it necessary to test the cable before it is electrically commissioned?
- (ii) What precautions are to be observed while carrying out the insulation test?
- (iii) Why is it necessary to discharge the respective cores of the cable after the test?
- (iv) What is the minimum permissible value of insulation resistance for cables?

ACTIVITY NO. 34

Termination of Cables in a Pot-Head

Specific Objectives

The students should be able to:

- (i) prepare cable core conductor leads to the required dimensions;
- (ii) terminate the cable in the pot-head and seal.

Related Information

When the underground PILDSTA cables core conductors' ends are to be connected with overhead transmission or distribution mains, the armours and paper insulation are to be removed to some extent and, thus, the mechanical and electrical protection provided by them gets impaired. This makes the cables liable to damage because of possible mechanical damage and absorption of moisture. In order to re-provide the mechanical strength and insulation protection, the terminated ends are fixed with a specially designed terminating box known as a pot-head cable joint box. After termination and connection of the cable, this is sealed by filling in the Bitumen com-

pound. Connection of a pot-head cable shown in Fig. 34.1.

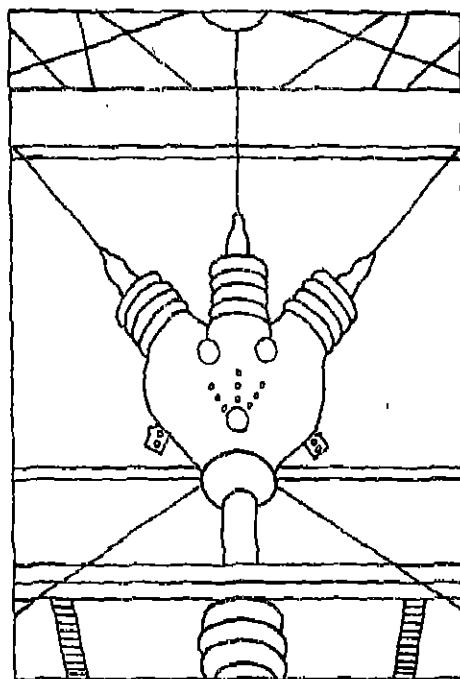


Fig. 34.1 A Pot Head Cable Terminating Box

Equipment and Materials

- (i) Cable length (PILDSTA)
- (ii) Pot-head joint box
- (iii) Brass sleeve for accommodating the groove of the pot-head joint box.
- (iv) Soldering lugs/solderless crimping type lugs.
- (v) Soldering material and soldering tool kit crimping tool kit.
- (vi) D.E. spanner set
- (vii) Flat file 25 cms.
- (viii) Triangular file 20 cms.
- (ix) steel binding wire 14 SWG
- (x) Hylam sheet 30 cms. x 20 cms. x 15 cms.
- (xi) Cable jointing tool kit.
- (xii) Firewood
- (xiii) Bitumen compound
- (xiv) Insulation tester
- (xv) Tallow
- (xvi) Empire tape
- (xvii) High tension insulation tape
- (xviii) Tallow cloth
- (xix) White cotton tape
- (xx) Kerosene oil
- (xxi) Markin cloth 2 mts.
- (xxii) Bricks-8
- (xxiii) Emery paper No. '0'
- (xxiv) Cotton waste.

Procedure

- (i) Lay the PILDSTA cable on the ground and support it on a wooden box near its end.
- (ii) Dismantle the top lid of the pot-

head junction box.

- (iii) Take the measurements for preparation of the ends of core conductors, taking into account the pot-head's inner dimensions.
- (iv) Prepare the cable ends for jointing as explained in activity no. 28 on "Preparation of Cable ends for Jointing".
- (v) Pass the cable through the brass sleeve so that it comes over the portion of the exposed lead sheath.
- (vi) Solder/crimp the lugs with the ends of the core conductors of the cable.
- (vii) Insert the core conductors inside the pot-head junction box and tighten them with the insulated terminals inside the box.
- (viii) Ensure that the brass sleeve sits in the appropriate groove provided for it and that a portion of the exposed lead sheath remains outside the pot-head junction box for plumbing.
- (ix) Provide the hylam spacers between the core conductors inside the pot-head junction box.
- (x) Test the cable for continuity and insulation resistance through the outlet terminals of the pot-head.
- (xi) Melt the Bitumen compound and pour into the box as explained in activity no. 31 on Straight through Joint in U.G. Cables.
- (xii) Do the plumbing over the brass

sleeve and lead sheath of the cable as explained in activity no. 31 on "Straight Through Joint Box".

- (xiii) Assemble the top lid of the pot-head joint box and tighten with nuts and bolts and allow the box to cool.
- (xiv) After cooling, re-check the cable through the pot head outlet terminals for continuity and insulation resistance as explained in activity no. 33 on "testing of U.G. Cables."
- (xv) Fix up the mounting clamps on the cable near the plumbing.

Note:

Since Tropodure cables do not absorb moisture, pot heads are not generally provided with them. When it is essential

to provide them, they are sealed with Araldite based sealing compound as supplied in the M-seal kit.

Precautions

- (i) In case the porcelain sleeve insulators are provided over the connecting terminals with the pot head, ensure that they are not mechanically damaged during the process.

Questions

- (i) Why is it necessary to test the cable through the terminals of the pot-head joint box before filling in the compound?
- (ii) Why is it necessary to do plumbing over the brass sleeve and lead sheath?

ACTIVITY NO. 35

Listing and Mounting of Jointed Cable Assembly on the Pole and Connecting with Overhead Lines

Specific Objectives

The student should be able to:

- (i) Select proper tools and tackle;
- (ii) Lift and mount the jointed cable assembly on the over-head line structure.
- (iii) Lift the output terminals of the joint-box with the overhead mains.

Related Information

In the 11 KV/6.6 KV/3.3 KV system, connections from the over head lines are taken through cables laid underground to the sub-station equipment, consumer's equipment, transformers, indoor switch-gears bus, etc. For such connectins, the under-ground cables are terminated in suitable pot-head type cable joint boxes which are mounted onthe overhead line structure which may be a terminal pole or intermediate pole.

The connections between the overhead line conductors and cables box terminals are done by means of suitable jumpers.

In the case of the 415 volts secondary distribution line, the connections from the sub-station/L.T. distribution transformer to the feeder lines are also done in this manner.

For feeding or tapping the connections from overhead lines the pot-head jointed cables are required to be lifted and mounted or clamped on the poles for mechanical support. This is illustrated in Fig 35.1.

Equipment and Materials

- (i) Pot-head joint box with cable assembly.
- (ii) Flexible steel rope sling having eye loops at both ends.
- (iii) Two lengths of Manila ropes, 25 mm diameter 40 mts and 15 mts,
- (iv) Snatch block or single sheave pulley.
- (v) Nuts and bolts.
- (vi) Soldering Material and Soldering tool kit Crimping tool kit.
- (vii) Soldering lugs/solderless

crimping type lugs.

- (viii) Binding wire/P.G. clamps.
- (ix) Hacksaw with blade
- (x) D.E. spanner set.
- (xi) Screw driver 30 cms.

Procedure

- (i) Before mounting the joint box assembly, ensure that the channel/angle iron fitted on the pole for this purpose is securely clamped to the pole. Also check the holes drilled for mounting the cable box on the angle iron/channel.
- (ii) Hang the snatch block/single sheave pulley with the help of a flexible steel rope from the uppermost channel/angle cross-arm.
- (iii) Tie one end of the Manila rope (40 mts. length) securely with the pot head assembly and bring the other end of rope over the snatch block/single sheave pulley.
- (iv) Tie the second Manila rope (15 mts length) around the middle portion of the pot-head assembly to keep it slightly away from the pole structure so that it does not collide with the first one.
- (v) Pull upwards the pot-head assembly by the rope over the snatch block/pulley and simultaneously the assembly should be held away from pole structure by pulling the rope tied in the middle of the assembly. One workman should be deployed to train the cable in the direction being pulled to avoid bending or kinking.
- (vi) As the pot-head assembly reaches over the mounting channel/angle; climb up and train the assembly to that its holes coincide with the respective holes made on the channel/angle, and fix with the nuts and bolts.
- (vii) During this exercise, act as a group leader to give guidance and directions to the workmen to pull upwards/sideways to hold, to align, etc.
- (viii) Untie the ropes and remove. Also bring down the snatch block/pulley.
- (ix) Prepare the three lengths of jumpers by soldering/crimping the lugs at one end.
- (x) Connect the lugs with the outgoing terminals of the pot-head assembly with nuts by providing suitable washers.
- (xi) Connect the other end of the jumpers with the over head lines, either by binding with suitable binding wire or through parallel group (P.G.) clamps.

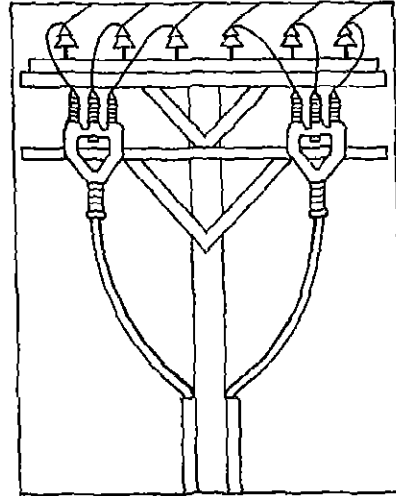
Precautions

- (i) If the pot-head joint box is to be mounted on a line which is already in service, take proper line clearance. Ensure that the

- line is isolated and earthed.
- (ii) While lifting the pot-head assembly by coverful that it does not touch collide with the pole structure.
 - (iii) Also, during the process of lifting, ensure that the cable does not get any bend or kink.
 - (iv) While connecting the jumpers with the line, ensure the phase sequence.
 - (v) The length of the jumpers should be such that they are loose enough to avoid any stresses on the line conductors but also remain free of the structure during strong winds/storms.

assembly on a pole having line in Service?

- (iii) What points are kept in mind while deciding the length of jumpers?



Questions

- (i) Where do we use a pot-head cable assembly joint-box?
- (ii) What Precautions are observed while mounting the pot-head

Fig. 35.1 A View of a Pot Head Joint Box and cable. Assembly mounted on O/H Pole.

ACTIVITY NO. 36

Erection of a Feeder Pillar Box

Specific Objectives

The Students should be able to:

- (i) select, place and make the foundation for a feeder pillar box.
- (ii) erect a feeder pillar box.
- (iii) connect the incoming feeder and outgoing feeders maintaining the phase-sequence.

Related Information

In areas where the distribution on H.T./L.T is to be made through underground cables from the distribution centre/sub-station, the cables are connected to the main bus bars in the centre/sub-station through control and protective equipment, etc. and taken to different directions. In order to save the high cost and for greater convenience, one feeder cable is laid in the duct all along the common route and terminated at the bus bars mounted in the M-S. cubicle box having proper built-in locking arrangements erected on the ground. This box is called the feeder pillar box from

where the connections are taped for different branch circuits.

Feeder pillar boxes are erected at places where it is preferable not to have the joint in that cable buried in the trench owing to certain reasons, or when different types or sizes of cables are to be jointed together, or in areas where due to congestion or obstacles, the distribution feeders are constructed partly through U.G. cables and partly through overhead lines.

In the event of any fault in any of the outgoing cables, this system allows quick location of the fault and isolation of the same, thereby ensuring uninterrupted supply to the healthy feeders. This is shown in Fig 36.1.

Equipment and Materials

- (i) Feeder pillar box.
- (ii) Lengths of cables with prepared ends of core conductors having soldered/crimped lugs of the required size.

- (iii) Suitable foundation bolts.
- (iv) Cement, sand, bricks, etc.
- (v) White and red, luminous water-proof paints.
- (vi) Painting brush.
- (vii) Cut-stencil for caution mark in Hindi and in the Regional language.
- (viii) G.I. wire 6 S.W.G.
- (ix) Brass bolts, nuts and washers.
- (x) Insulation tester.
- (vii) Earth the box at least at two places.
- (viii) Lock the doors through the built-in-lock.
- (ix) Paint the upper half of the front and back of the box, with luminous water-proof white paint.
- (x) Paint the caution mark with the red luminous water proof paint through the cut-stencil over the white background.

Procedure

- (i) Select the place for erecting the feeder pillar box on the cable route, but off the road.
- (ii) Dig the trench deep enough to take the curved cables.
- (iii) Get a mason to make the foundation and grout the foundation bolts in accordance with the holes of the base plate of the feeder pillar box.
- (iv) After the foundation is set, erect the feeder pillar box on the grouted bolts and tighten the nuts.
- (v) Bring the cables through the deep dug trench inside the feeder pillar box and connect to the bus bars with the brass nuts, bolts and washers etc.
- (vi) Conduct continuity and insulation resistance tests from the bus bars as explained in activity no. 33 on "Testing of Underground Cables".

Tabular Records of Observations

(A) Continuity Test.

R-Y	Y-B	B-R	R-N
-----	-----	-----	-----

(B) Insulation Resistance between conductors

R-Y	Y-B	B-R	R-N	Y-N	B-N
-----	-----	-----	-----	-----	-----

(C) Insulation resistance between conductors and earth

R-E	Y-E	B-E	N-E
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Precautions

- (i) The location of the feeder pillar box should be away from all types of traffic.
- (ii) The trench beneath the feeder pillar box should be sufficiently deep so that the cables may be properly curved.
- (iii) The foundation of the feeder pillar box should be made sufficiently high above the ground level so that the rain does not get inside.
- (iv) Before the feeder filler box is erected, the foundation must be allowed to set properly.
- (v) The caution mark must be so painted that it is prominently visible to everyone.

- (vi) Proper earthing of the feeder pillar box is most essential.

Questions

- (i) Why is the foundation for the feeder pillar box made above the ground level?
- (ii) What points are to be kept in mind while selecting the location for the erection of the feeder pillar box?
- (iii) Why is it essential to provide proper earth connections to the feeder pillar box?
- (iv) Why is it required to paint the caution mark with luminous water-proof paint.

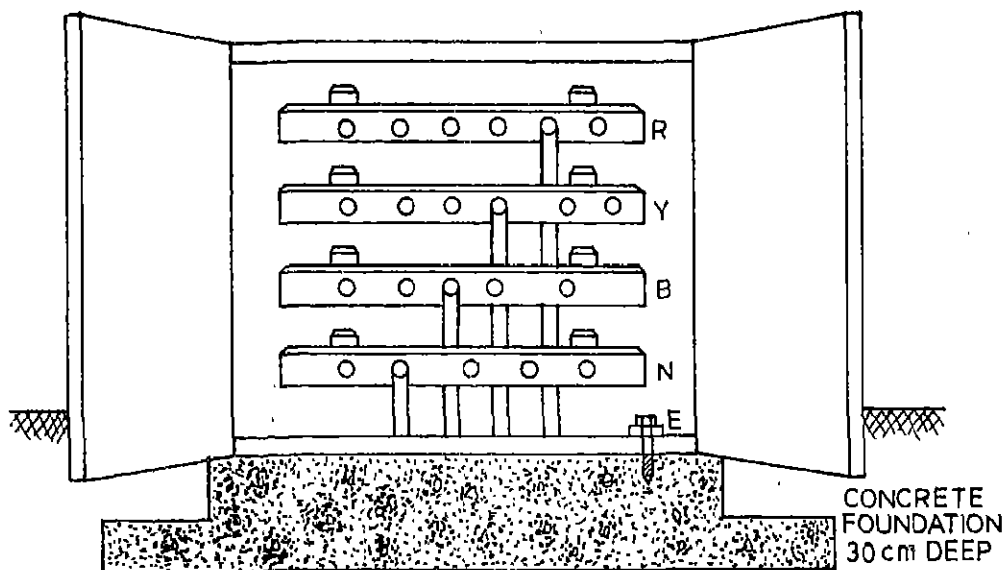


Fig. 36.1 Feeder Pillar Box

Method of Mounting a Pole Type Transformer and Its Connections

Specific Objectives

The students should be able to:

- (i) select the tools and accessories needed for lifting and mounting the transformer on a pole.
- (ii) lift and mount the transformer on a pole.
- (iii) connect the transformer through accessories with H.T. and L.T. mains.
- (iv) lead a group of workmen for safe completion of the job.

Related Information

For giving power connections in rural areas, transmission lines upto 11 KV are normally terminated on double pole structures. Distribution transformers of 11 KV/0.5 KV or 6.6 KV/0.4 KV rating are mounted on such double pole structures and connected through control and protective accessories with the H.T. and L.T. mains.

In urban areas, where making an electric sub-station on the ground is not pos-

sible either due to scarcity of land or because of congestion and also where there is not much demand for power, this method of mounting the transformer on pole structures is preferred.

This type of arrangement is quite economical since it does not require any extra land foundation and other allied structures or accessories. This is shown in Fig. 37.1.

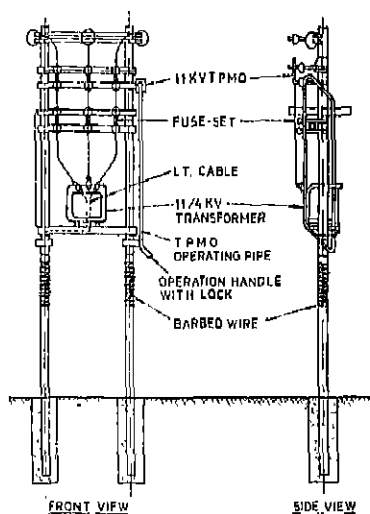


Fig. 37.1 11/0.4 KV Pole Mounted Transformer with complete connection.

Equipment and Materials

- (i) Transformer 11 KV/0.4 KV or 6.6 KV/0.4 KV or 3.3 KV/0.4 KV (select according to the primary distribution voltage) 25 KVA fitted with mounting channel at the bottom.
- (ii) Drop-over fuse complete sets.
- (iii) Triple pole mechanically operated switch 11 KV.
- (iv) Snatch block or single shieve pulley.
- (v) Manila rope 50 meters length and 25 metres-2 pieces.
- (vi) D.E. spanner set (25 mm-50 mm).
- (vii) Screw driver 30 cms.
- (viii) Insulated combination pliers-20 cms.
- (ix) U-bolt (D-shackle) 2
- (x) Flexible steel rope sling-1.5 mts. having eye loops at both ends.
- (xi) Steel wire sling 7/10 or 7/8 S.W.G.-2 metres.
- (xii) M.S. nuts and bolts
- (xiii) Tin packing pieces (wedges)
- (xiv) Hacksaw with blade
- (xv) Aluminium conductors 30 mm² x 20 mts.
- (xvi) Aluminium lugs/solderless crimping lugs.
- (xvii) Soldering/crimping tool kit.
- (xviii) Barbed wire 4 metres.
- (xix) G.I. wire 6 SWG-10 metres.
- (xx) Cotton waste.
- (xxi) Emery paper no. '0'.
- (xxii) Adjustable slide wrench 30

cms.

- (xxiii) Aluminium binding wire/P.G. clamps.

Procedure

- (i) Before mounting the transformer, ensure that the base angles, channels for fuse sets, triple pole mechanically operated (T.P.M.O.) switches are firmly fitted on the double pole.
- (ii) Hang the flexible steel rope sling on the top channel and also hang the snatch block or single sheave pulley with the sling.
- (iii) Fix the steel wire sling with the two hooks provided on the transformer or if the transformer is fitted with the eye bolt, attach the sling with the eye-bolt, by means of a U-bolt (D-shackles).
- (iv) Tie up one end of the Manila rope at the centre of the sling fixed as step (iii). Bring the other end of the rope over the snatch block of the single sheave pulley.
- (v) Tie the small rope around the middle of the transformer for pulling it away from the support so that it may not touch or collide with the base angle or structure, while lifting.
- (vi) Put the workmen (as many required) to lift the transformer by pulling the main rope and hold it over the base angle. While lifting the transformer one of the

- workmen may be required to pull the small rope so that the transformer remain away from the structure.
- (vii) During the above process, act as the group leader and direct the workmen properly for lifting and mounting the transformer and for lifting and mounting on the base angle, i.e. when to pull or stop, loosen or deviate.
- (viii) When the transformer is being held above the base angle, climb up to the base angle and instruct the workmen to loosen the rope gently and intermittently.
- (ix) As the transformer reaches about 5 cms above the base angle, train it in such a way that its fixing holes in the bottom coincide with the holes in the base angle. If necessary, make use of the screw driver.
- (x) When the transformer has been seated on the base angle properly and the holes coincided, fasten it by nuts, bolts and suitable washers.
- (xi) Untie the ropes from the sling and transformer and remove the ropes, slings, snatch block, etc.
- (xii) Assemble the three fuse sets on the cross channels already mounted, sufficiently above the transformer, by placing proper insulation like hylam spacers between the fuse and channels, and tighten the nuts.
- (xiii) Assemble the triple pole mechanically operated switch's male and female contacts in a similar way on the channels above the fuse sets. Also ensure that the movable rod of the contacts in properly attached to the operation handle.
- (xiv) Check the proper opening and closing of contacts by repeatedly operated through the operation rod. Also check the lock.
- (xv) Provide two earth connections to the transformer through 6 SWG G.I. wires with the earth electrodes already provided near the bottom of the poles.
- (xvi) Measure and cut three sets of bare aluminium conductor lengths for connecting (a) the transformer's H.T. input terminals with fuse sets; (b) the fuse sets with the triple pole mechanically operated switch, (TPMO); and (c) the TMPO with the transmission line conductors.
- (xvii) Solder/crime the lugs at the pole ends of the first two sets

of conductors (a & b) and with one end of the set (c) and shape them according to the need of the connections.

- (xviii) Provide connections between the transformer H.T. input side and output terminals (bottom) of the fuse through the shaped conductors set (a).
- (xix) Interconnect the input terminals (top) of the fuse sets and the output terminals (bottom) of TPMS through the prepared conductors set (b).
- (xx) Also connect the lugged terminals of the prepared conductors set (c) with the input terminals (top) of TPMS and bind the other ends with the respective overhead transmission conductors with binding wire or tighten them with P.G. clamps.
- (xxi) Connect with L.T. cable ends, maintaining the sequence with the output L.T. terminals of the transformer and firmly tighten them.
- (xxii) Wrap the barbed wire for about 1 mt length on both the poles downwards beneath the operation handle. This is done to obstruct the climbing up on the poles of any unauthorized

person.

Precautions

- (i) Before lifting the transformer, ensure that the flexible steel rope sling, snatch block/single sheave pulley, etc. are properly hung.
- (ii) Also ensure that the sling is properly hooked/fastened with the transformer's hooks or eye bolts.
- (iii) Sufficient number of men are required to pull the rope while lifting the transformer.
- (iv) While lifting the transformer, see that it does not collide with the poles or structure.
- (v) Conductor leads to be used for connections should be cut to the exact lengths required, and shaped.
- (vi) All the bolts and nuts should be firmly tightened preferably using spring washers and lock nuts.
- (vii) Lugs should also be securely soldered/crimped with conductor ends.
- (viii) While connecting with the input and out terminals of the transformer, the proper phase sequence must be followed, otherwise accidents may be caused at consumer's load ends.

Questions

- (i) Why is it essential to take care of phase sequence while connecting

- the leads with the transformer?
(ii) Why is barbed wire wrapped on both poles?
(iii) What is the purpose of providing the triple pole mechanically operated switch (TPMO)?
(iv) How and why is the transformer earthed?
(v) How do we align the fixing holes of a transformer with those on the base angle?
(vi) Why it is essential for a lineman to have the qualities of leadership in him?

APPENDIX

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